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METHODOLOGY INVESTIGATION

FINAL REPORT

HUMAN FACTORS JUNGLE TEST AREA RELOCATION

by

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APRIL 1982

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UNITED STATES ARMY TROPIC TEST CENTER

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The implementation of the Panama Canal Treaty (1 October 1979) necessitated the relocation of the US Army Tropic Test Center (USATTC) Gamboa A-1 test area. The relocation effort involved site selection, preparation, and a conceptual validation of the USATTC Human Factors Jungle Test Area (HFJTA). The HFJTA is composed of several independent test sites--the manpack portability course, the land navigation site, the sound localization site, the target detection site, and the rifle marksmanship site.

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The relocation task was completed and recommendations were for future efforts to focus on automating data acquisition and analysis, upgrading safety procedures, and revising appropriate test operation procedures.

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FOREWORD

This methodology investigation was conducted by a task group from the US Army Tropic Test Center (USATTC). USATTC was responsible for planning, conducting, and reporting on this investigation. Augmenting the task group were Jack P. Henley, a geologist from the US Army Waterways Experiment Station, and Melvin B. Satterwhite, a botanist from the US Army Engineer Topographic Laboratory. Robert Johnson, USATTC Soils Engineer, collected and compiled the slope data and analyzed the soils data presented in Appendix B.

This methodology investigation resulted in the relocation of the US Army Tropic Test Center's Human Factors Jungle Test Area. Two of the test sites were upgraded significantly. The manpack portability course was restructured into a more arduous and flexible configuration, and the rifle marksmanship site was revamped into a more realistic structure. Recommendations for future development center on implementing automated data acquisition and analysis, standardizing methodology and report formats, upgrading safety procedures, and revising appropriate test operation procedures.

SECTION 1. SUMMARY

1.1 BACKGROUND

a. Until October 1979, the US Army Tropic Test Center (USATTC) operated environmental test facilities, including a Human Factors Jungle Test Area (HFJTA), at the Gamboa A-1 test area, a 20,000-acre test area in the central portion of the former Canal Zone. These sites were used for soldier-materiel testing to determine the effects of the environment on the item and on the performance of the soldier who wore or used the materiel item. The HFJTA consisted of a land navigation site, a sound localization site, a manpack portability course (MPPC), a target detection site, and a rifle marksmanship site, all located within the Gamboa A-1 test area. The sites were constructed so that they could be used either in a stand-alone configuration or in conjunction with each other; e.g., use of the land navigation site by itself as a measure of materiel effects on land navigation or as a before and after measure to determine the effects of transporting a materiel item on a jungle patrol such as the MPPC. The treaties between the United States and the Republic of Panama caused the Gamboa A-1 test area to revert to Panama's jurisdiction on 1 October 1979.

b. The existence and operation of the HFJTA provided a valuable standardized frame of reference for soldier-materiel evaluations. The realistic, objective test capability of the HFJTA resulted in more valid decisions regarding the development and acquisition of US Army equipment and materiel. The continued need for soldier-materiel item testing prompted the selection of an area with the proper characteristics to which the HFJTA could be relocated. This action was directed by the US Army Test and Evaluation Command (TECOM) Test Execution Directive (Appendix A).

1.2 OBJECTIVE

Relocate the HFJTA to an area that will be available during the life of the Panama Canal Treaty.

1.3 SUMMARY OF PROCEDURES

a. Individuals from USATTC formed a task group to select an appropriate site to which the HFJTA could be relocated. The task group was assisted by a geologist from the US Army Waterways Experiment Station (USAWES) and a botanist from the US Army Engineer Topographic Laboratory (ETL). Different areas were surveyed and analyzed for slope, vegetation, and soil characteristics. The Cerro Pelado area, just north-northwest of Gamboa, was selected as the new location for the HFJTA. This new area, approximately 2.4 square kilometers, contains dense tropic forest varying in age from early secondary to 50 years, small streams, marshland, and relatively flat savannah grass. The area is bordered on the east by the Chagres River. According to the Holdridge Life Zone Classification System (reference 1), the vegetation is tropical moist forest. Survey data (slope) are included in table B-1 and soils data are included in table B-2. Figure 1 shows the locations of the old and new HFJTAs.

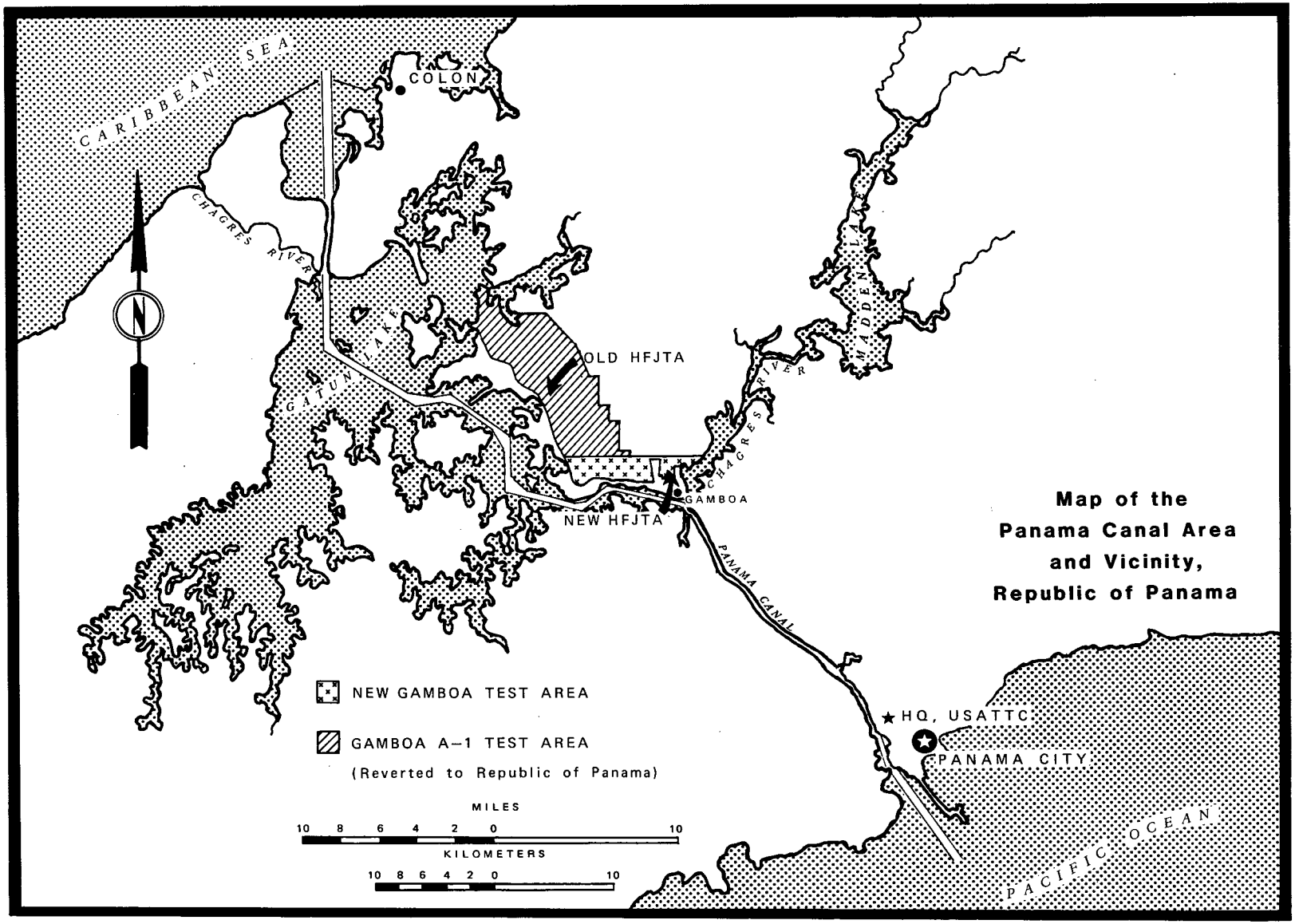

Figure 1. Locations of Old and New Gamboa Test Areas.

b. The new MPPC was outlined to begin and end around the base operations area (BOA) and to parallel access roads enabling multiple entrance and exit points. Other test sites were located close to the BOA (as shown in figure 2), between the start and finish of the MPPC. Sites can be used as isolated measures of individual tasks or in conjunction with the MPPC course as before and after measures of performance. Baseline data were collected from each site, and evaluations were made on ease of use and accuracy of results. The intent was to determine if the sites were conceptually valid based on actual use and professional opinion.

1.4 SUMMARY OF RESULTS

a. The new HFJTA consists of an MPPC, a land navigation site, a target detection site, a sound localization site, a rifle marksmanship site, and a BOA, as shown in figure 2.

b. The various sites have been replicated or upgraded at the new HFJTA. In addition to its improved, modular configuration, the new MPPC is situated in a more rugged terrain that enhances the ability to surface soldier-item problems. The target detection site has been relocated into a representative, level humid tropic location. The sound localization site has been relocated to a relatively flat location where the speakers cannot be detected visually by the test participants, and can be positioned at 30-meter intervals up to a distance of 120 meters. The rifle marksmanship test was relocated to a site where operational realism and credibility to participants were improved.

1.5 ANALYSIS

a. The land navigation site, ground-to-ground target detection site, and the sound localization site have been reinstated without major modification. The physical structures, operating procedures, and data elements remain unchanged. TOP 1-1-054 (reference 2) contains the background and operating procedures for the ground-to-ground target detection site. TOPs do not exist for either the land navigation or sound localization site. Currently, guidance for the land navigation test is contained in USATTC Report No. 7610001 (reference 3), and guidance for the sound localization test is contained in a USATTC letter (reference 4).

b. The MPPC and the rifle marksmanship site received major modification. The physical structures, operating procedures, and data elements were all changed. Previously, guidance for the MPPC was obtained from TOP 1-3-550 (reference 5), and guidance for the rifle marksmanship site was obtained from USATTC Report No. 7603001 (reference 6).

c. The BOA was upgraded to include commercial power, two 6- by 7-meter open-sided sheds, and a 2-meter high security chain link fence.

d. Baseline data were collected from each site and evaluations were made on ease of use and accuracy of results. The intent was to determine if the sites were conceptually valid, based on actual use and professional opinion.

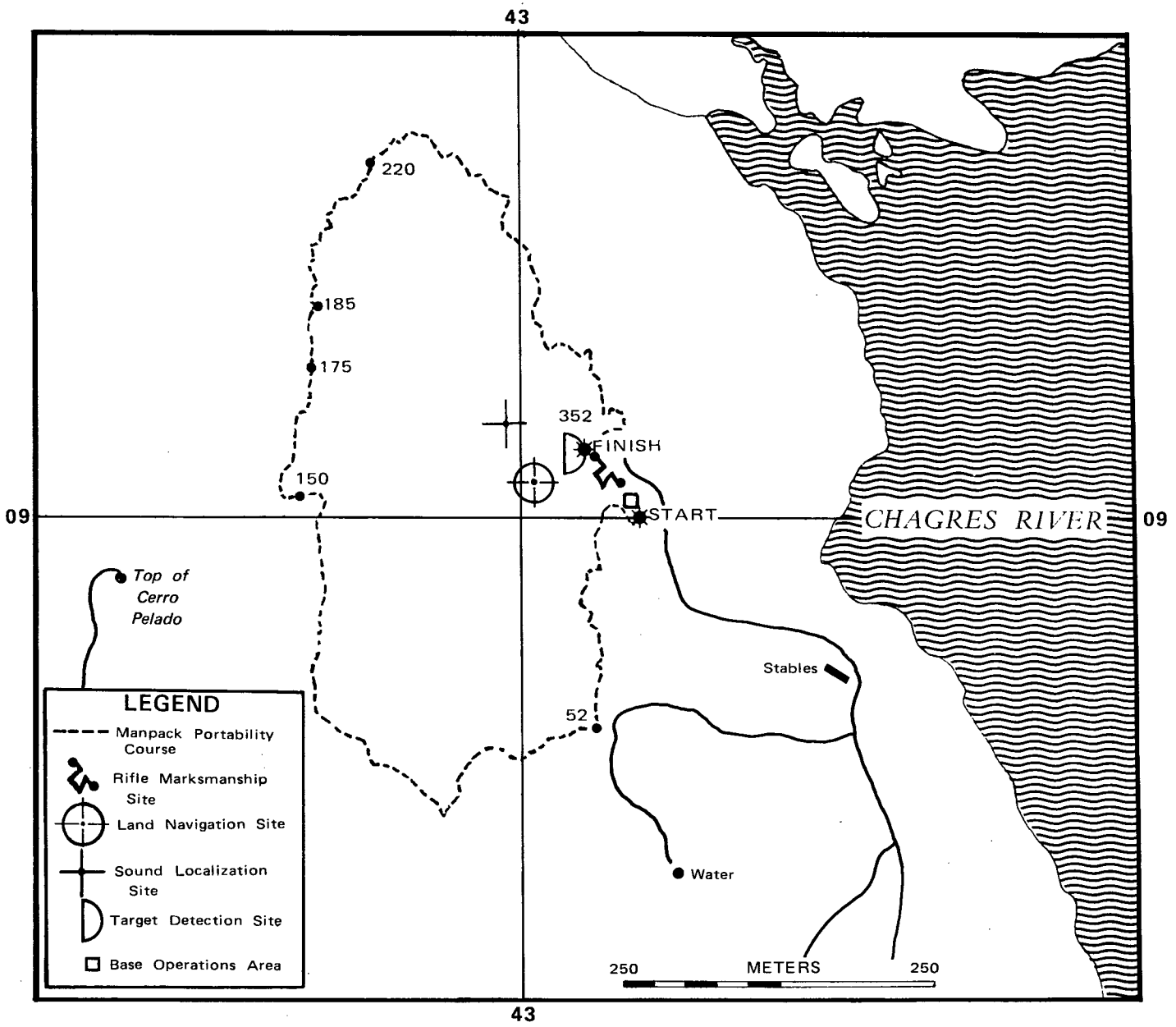

Figure 2. HFJTA Outline.

1.6 CONCLUSIONS

a. The sites are conceptually valid for future data collection efforts. However, some improvements are necessary in documenting for operational procedures and in instrumentation.

b. The relocation effort is a success. The improved, modular MPPC is more rugged and flexible.

c. The rifle marksmanship site has been upgraded in operational realism, but requires more modification in data acquisition procedures and instrumentation to yield a higher degree of realism and a more precise measure of rifle-fire accuracy.

d. The current configuration of the HFJTA can be adapted easily to the single-course concept. There may be a distinct advantage to combining all task elements into a single unit scenario that would include detecting targets visually and aurally, and engaging them while accomplishing land navigation on the MPPC.

e. The HFJTA, in its current configuration, has adequate space to incorporate other standardized test sites that would measure additional soldier-item problems.

1.7 RECOMMENDATIONS

a. Evaluate each test site for potential automatic data collection and analysis methodology and for the use of instrumentation required to minimize man-hour and time requirements and to maximize the accuracy, reliability, and validity of the information obtained from the sites.

b. Modify the BOA to allow on-site, computerized data acquisition and analysis. This could be accomplished by either adding a building or by using an instrumented vehicle.

c. Develop a safety SOP and emergency evacuation procedures for the HFJTA, with emphasis on the MPPC, and upgrade current communication links between the site and USATTC.

d. Explore a single-course concept wherein all tasks (aural and visual detection, land navigation, rifle marksmanship) would be combined into one test that would be conducted under realistic operational conditions.

e. Develop or revise TOPs for all test sites and prepare seasonal normative data.

f. Further modify the target detection site to even out the vegetation density throughout the field-of-search. Explore procedures and instrumentation to upgrade the operational realism of the rifle marksmanship site. Change the rifle marksmanship site instrumentation and data from binomial to integral ratio data elements to increase the statistical power of the data analysis.

SECTION 2. DETAILS OF INVESTIGATION

2.1 BASE OPERATIONS AREA (BOA)

a. Rationale. The BOA should be a permanent, centrally-located, cleared, and secure area. The BOA should provide staging and debriefing facilities, as well as serving as the first-line data processing facility.

b. Description. The BOA is a centrally located, 22- by 32-meter area located at the entrance to the forest. This area includes facilities such as 120/240-volt commercial power; two 6- by 7-meter open-sided sheds for troop staging, preparation, and debriefing; and a 2-meter chain link fence around the base station for added security.

c. Validation. The BOA was not completed at the time of site validation.

2.2 MANPACK PORTABILITY COURSE (MPPC)

a. Rationale. The MPPC should be a permanent test facility designed to allow USATTC to collect valid and reliable objective and subjective data in a highly realistic, yet experimentally controlled, jungle environment. Three essential types of data should be provided by the MPPC: (1) soldier opinion of the item; (2) objective evaluations of the soldier-item interactions; and (3) item ruggedness evaluations. All three types of data are acquired in a highly realistic environment and possess a corresponding high level of face validity. The experimental control assures enhanced reliability characteristics. The degree of ruggedness of the course should be representative of areas in the world where jungle combat patrols would be conducted. This would require sufficient ruggedness to achieve realism (and consequently, face validity) while allowing adequate control to obtain reliable data. The relocated MPPC is described below.

b. Description.

(1) The MPPC is located within the 2.4-square-kilometer area selected for the HFJTA. It is a 3.35-kilometer trail through rugged jungle terrain. The trail starts south of the BOA, passes through streams, marshes, hills, gullies, borders the skirts of Cerro Pelado, and ends north of the BOA. The course begins on flat terrain, proceeds sharply upward, turns right to traverse the hill just below its summit, turns right, proceeds downhill, and ends on relatively flat, marshy land. Survey data (slope) are presented in table B-1. This course tests the interactions/relationship of the tropics (jungle environment and terrain), soldiers, and test items. The vegetation in the area of the MPPC is classified in the "tropical moist forest" life zone according to the Holdridge System. Several vegetation associations exist based on drainage considerations and previous disturbance (clearing) of the forest. The beginning and ending sections of the course are on flat, poorly drained soil which supports a forest dominated by palm species. The middle section of the course is located on higher, better drained soil which supports more deciduous tree species, although palms are still common. Soils data are presented in table B-2.

(2) The forest throughout the course shows evidence of disturbances in the last 50 years. Flat areas of the course support the least mature forests. These forests are characterized by a poorly developed canopy and a dense understory of shrubs and immature trees. On the slopes, the forests are more mature with dense canopy and more open understory. The most mature forests occur near the summit of Cerro Pelado (markers 150-160).

(3) The vegetation characteristic which will most influence personnel traversing the course is the occurrence of armed palms (Astrocaryum standleyanum, Bactris major, and Cryosophila warscewiceii). Armed palms have sharp spines which can penetrate clothing and skin easily. They are common throughout the course and are a realistic hazard, especially on steep portions of the course where people would have a tendency to use tree trunks for support. The soldier traverses the MPPC wearing or carrying the test item. The armed palms discourage the use of hands for support and balance. This handicap results in a rigorous test of the soldier-item compatability. Data also are collected on soldier performance before and after traversing the MPPC to determine any performance degradation because of soldier-materiel-tropics interactions. Figure 3 is an aerial view of the relocated HFJTA. Figures B-1 and B-2 are representative photographs of soldiers traversing the MPPC.

(4) As shown in figure 2, the MPPC trail is marked systematically with consecutively numbered metal plates (1 through 352) indicating the route to be traversed. Portions of this course were selected for timed events; for example, an uphill climb and a patrol through marshland (a vertical profile is shown in figure 4). The total course is modular in nature; i.e., any event can be used in isolation and multiple entrance and exit points can be provided. The other sites, installed close to the beginning and end of the MPPC, can be used as before and after measures of performance degradation.

(5) Troop safety was a matter of primary concern during the design, layout, and construction of the MPPC. Trails have been routed so they intersect with future and existing roads which can be used for evacuating personnel in cases of emergency. The MPPC is also flexible. Its modular design provides multiple entrance and exit points so selected portions may be used, in any direction and in combination with other sites, depending on the requirements for the materiel item being tested.

c. Validation.

(1) Baseline data were collected using five- to six-person squads (N = 14). Before starting the course, the soldiers (test participants) were given instructions by the test officer on the purpose of the test. The squad leader was given a portable radio and assigned a call number. The squad members were instructed to start at marker 1 and follow consecutively numbered markers nailed to trees, to remain in single file approximately 2 meters apart, to keep together as a squad, and to proceed at their own collective pace. The squad leader was in radio contact with the test officer at the BOA and reported his position immediately before and after each rest break. The rest break did not exceed 5 minutes. Test personnel and medics were stationed

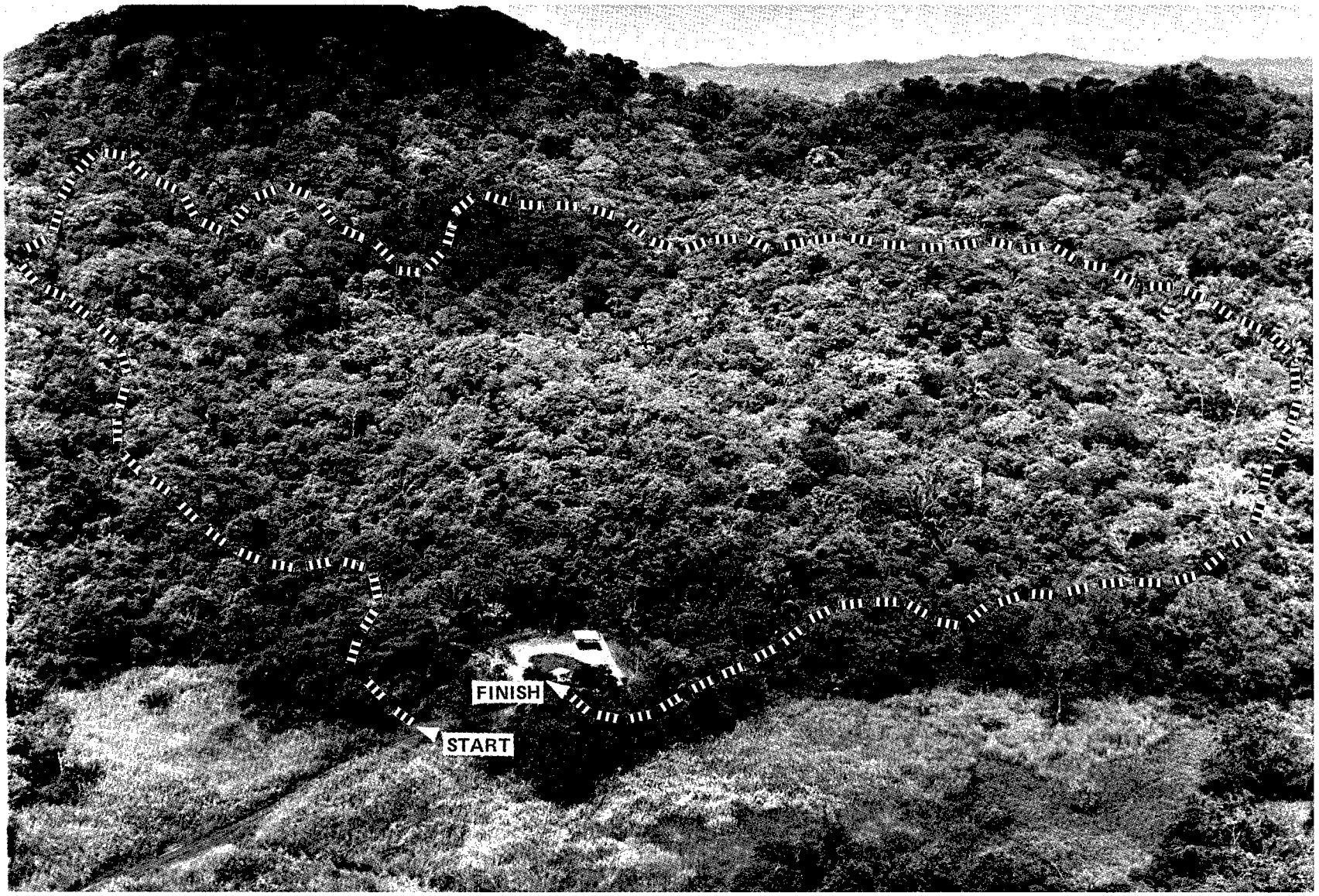

Figure 3. Aerial View of Relocated HFJTA with MPPC Outlined.

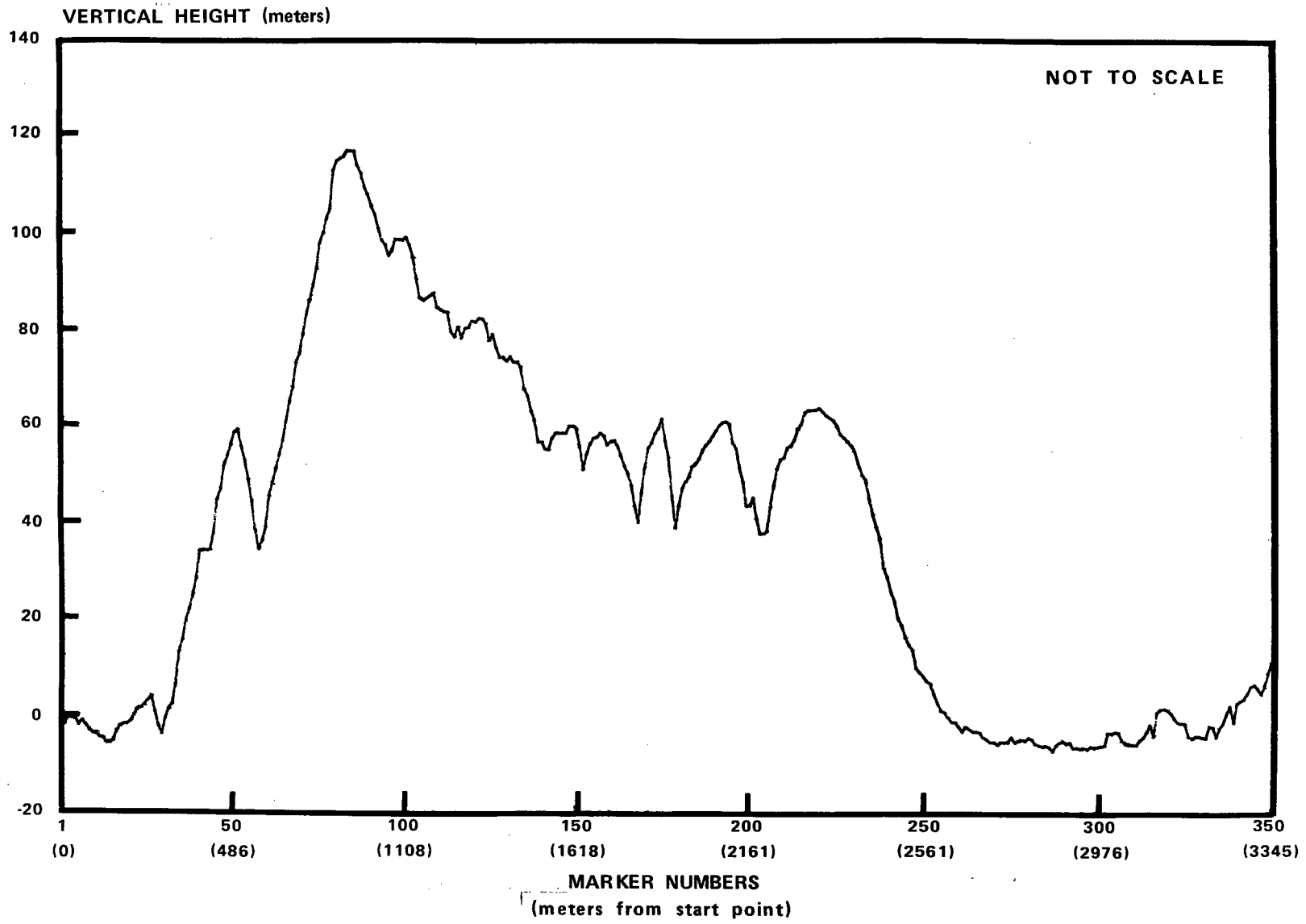

Figure 4. Vertical Profile of the MPPC.

at selected points throughout the course to time troops and to provide medical attention if necessary. Self-paced events were selected because previous experience with the old MPPC proved that total time and self-paced data were the most sensitive measures.

(2) Table 1 shows mean times and standard deviations for the selected areas. Means and standard deviations of the slope data are presorted for positive slope, negative slope, and absolute slope which indicates the overall terrain ruggedness for each segment. The slope index is a standard measure based on a right triangle with the base divided into the height and multiplied by 100. This provides a percent representation of the rise or fall of the hypotenuse. The actual survey data are presented in table B-1.

d. Analysis and Conclusions.

(1) The relocated MPPC is situated in more rugged terrain that increases the ability to surface soldier-item problems. This improvement over the old MPPC should provide data that are more sensitive to variations in materiel design. The most critical additions to the MPPC are the increased slope values. Aside from the greater relationship with predicted future tasks, the additional rigor enhances the value of the soldier's opinion and performance while putting realistic stress on the item and the soldier-item relationship.

(2) The measures used represent the best compromise of the old MPPC measures for sensitivity versus realism concerns.

(3) The MPPC has been relocated, upgraded, made more rugged, and converted into modular elements both in relationship to itself and to the other sites.

(4) The MPPC has been validated conceptually.

e. Recommendations.

(1) Revise TOP 1-3-550 to include new operating procedures.

(2) Consider incorporating automatic data processing (ADP) instrumentation and procedures.

2.3 LAND NAVIGATION SITE

a. Rationale. The land navigation site should be a permanent test facility designed to allow USATTC to collect valid and reliable objective and subjective data in a highly realistic, but tightly controlled scenario comprised of land navigation tasks accomplished in a jungle environment. The site should be capable of being used as a before and after measure of land navigation ability. The purpose of the before and after test is to determine the decrement in the ability of a soldier to perform a standard military task after having traversed the MPPC. The site also should allow for an independent measure of land navigation ability. The land navigation site should

TABLE 1. MPPC MARCH RATE DATA (N = 14)

MARKER FROM	MARKER TO	DISTANCE (m)	TIME IN MINTUES MEAN	S.D.	MIN	MAX	RATE (m/min)	MEAN POSITIVE SLOPE (%)	MEAN NEGATIVE SLOPE (%)	MEAN ABSOLUTE SLOPE (%)
M1	M30	279	6.36	0.93	3	8	44	9.1	-11.7	10.3
M30	M52	227	11.00	5.79	5	21	21	30.7	0.0	30.7
M52	M150	1113	44.00	10.75	30	65	25	20.3	-23.0	21.5
M150	M175	276	14.93	5.48	8	26	18	21.0	-27.5	24.1
M175	M185	124	8.00	2.86	5	15	16	21.9	-44.9	31.1
M185	M220	306	15.14	6.24	9	26	20	17.8	-44.6	23.9
M220	M352	1026	32.36	10.98	18	51	32	16.3	-17.9	17.3
M1	M352	3351	111.29	15.22	83	137	30	19.1	-21.2	20.1
Rest Time			20.50	18.04	0	48	--	--	--	--
Total Time			131.79	26.91	84	174	25	--	--	--

S.D. = Standard Deviation

provide measures of errors in land navigation, inferences of cognitive functioning in calculating distance traveled, and subjective opinions of the item. The jungle growth should be representative of areas where land navigation in the jungle would be conducted.

b. Description. The land navigation site (figure 5) is contained within a circle 60 meters in diameter. The circle is outlined by 96 metal stakes (figure B-3) representing arc segments (3°45') of the circle. The area within the circle is comprised of dense jungle foliage, complete with armed palms and thorny underbrush. A panoramic view from the center of the land navigation site is at figure B-4. The site produces both cognitive (distance estimation) and physical (traversing time) measures of performance, as well as stake errors, and can be used in isolation or as a before and after measure in conjunction with the MPPC. The relocated land navigation site is essentially the same as the old land navigation site. It is used to measure performance of soldiers on a standard military task. The soldier is given a lensatic compass and a card with six azimuths (one sequence) for him to accomplish (figure B-5). After he walks the first azimuth, he records the number of the stake he finds at the circumference of the circle and estimates the distance he has walked. He then continues with the same procedure for each of the remaining five azimuths. Measures consist of total time to complete a sequence, errors in estimating the distance walked for each segment, and number of stakes off for each segment.

c. Validation. Baseline means and standard deviations are presented in table 2. The dependent variables represented are distance traveled, estimated distance, and number of stakes off per sequence.

TABLE 2. BASELINE DATA FOR LAND NAVIGATION SITE

VARIABLE	MEAN	S.D.	MIN VALUE	MAX VALUE	STD ERROR OF MEAN
Distance Traveled (meters) per Sequence (N=72)	287.36	42.16	126.20	341.60	4.97
Estimated Distance (meters) per Sequence (N=72)	256.32	60.89	65.00	423.00	7.18
Number of Stakes Off per Sequence (N=72)	5.17	7.35	0.00	85.00	0.35

S.D. = Standard Deviation

d. Analysis and Conclusion.

(1) The land navigation site has been relocated. The physical site is centrally located. It can be employed in isolation or in conjunction with the

COMPASS COURSE PROBLEM AND SCORE CARD			
Problem Number	Azimuth	Stake Number	Number of Meters
1	325		
2	925		
3	242.5		
4	85		
5	235		
6	17.5		
Subject No.			
Name			
Date			
Elapsed Time (Nearest Second)	Min	Sec	

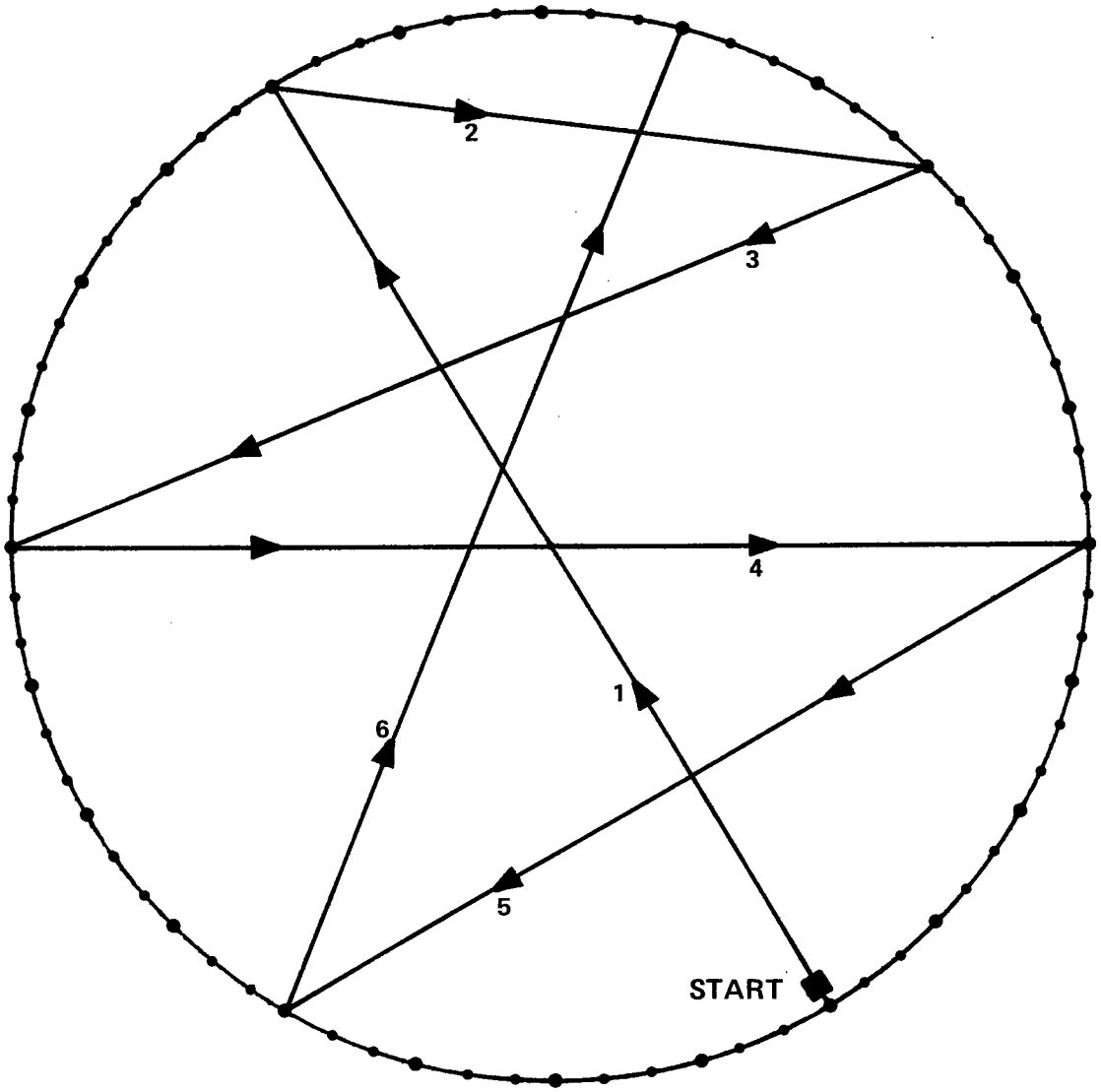

Figure 5. Diagram of Land Navigation Site and Sample Scorecard.

MPPC or any of the other sites. The relocated land navigation site is essentially the same as the previous land navigation site as described in USATTC Report No. 7610001.

(2) The land navigation site has been validated conceptually.

e. Recommendations.

(1) Develop a methodology that would minimize man-hour requirements and maximize automatic data acquisition and analysis.

(2) Develop a methodology to eliminate errors created by test participants' shooting azimuths which would lead them out of the land navigation site perimeter.

(3) Prepare a TOP for the land navigation site which includes seasonal (wet/dry) norms.

2.4 TARGET DETECTION SITE

a. Rationale. The target detection site should be used as a standardized measure to evaluate both the detectability of items and the degradation that test items may have on visual acuity. Target detection is a standard military task. Measures obtained are time-to-detect and detection distance. The site should have vegetation representative of the variations found in the lowland humid tropics; be relatively level, thus preventing physical obscuration of targets by unlevel terrain; and be located so large tree trunks or unusually thick vegetation do not completely obstruct any target location along the lane radii.

b. Description. The ground-to-ground target detection site has the same basic characteristics outlined in TOP 1-1-054. It is a semicircular area with a radius of 40 meters. It has six target walking paths (I through VI) which begin at the circumference and end at a distance 7 meters from the observation point. The observer has a 180-degree field of search, but targets only appear within a 160-degree field. Numbered stakes, 1 meter apart, mark the entire length of each target path. These stakes are used to record target positions when observers signal a visual detection. A diagram of the target detection site is shown in figure 6. Before participating in a target detection trial, observers are tested for visual acuity. Then a pretest briefing (outlined in Appendix B of TOP 1-1-054) is presented. Figures B-6 through B-8 show the sequence of events during a target detection trial.

c. Validation. Baseline data were gathered on the target detection site. Dependent variables were detection distance and detection probability. Figure 7 portrays the detection probability by lane, and figure 8 shows the detection probability of all lanes combined. Lane detection distances are presented in table 3.

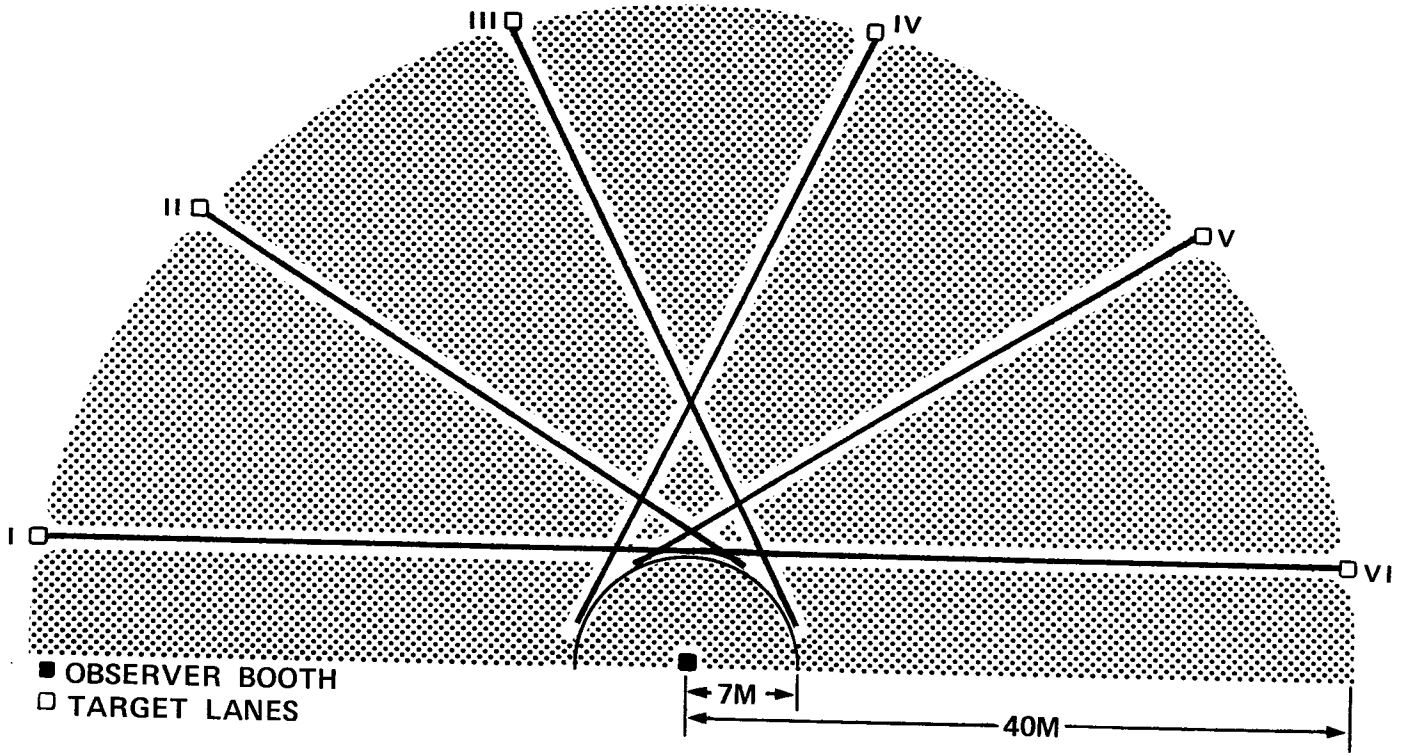

Figure 6. Diagram of the Target Detection Site.

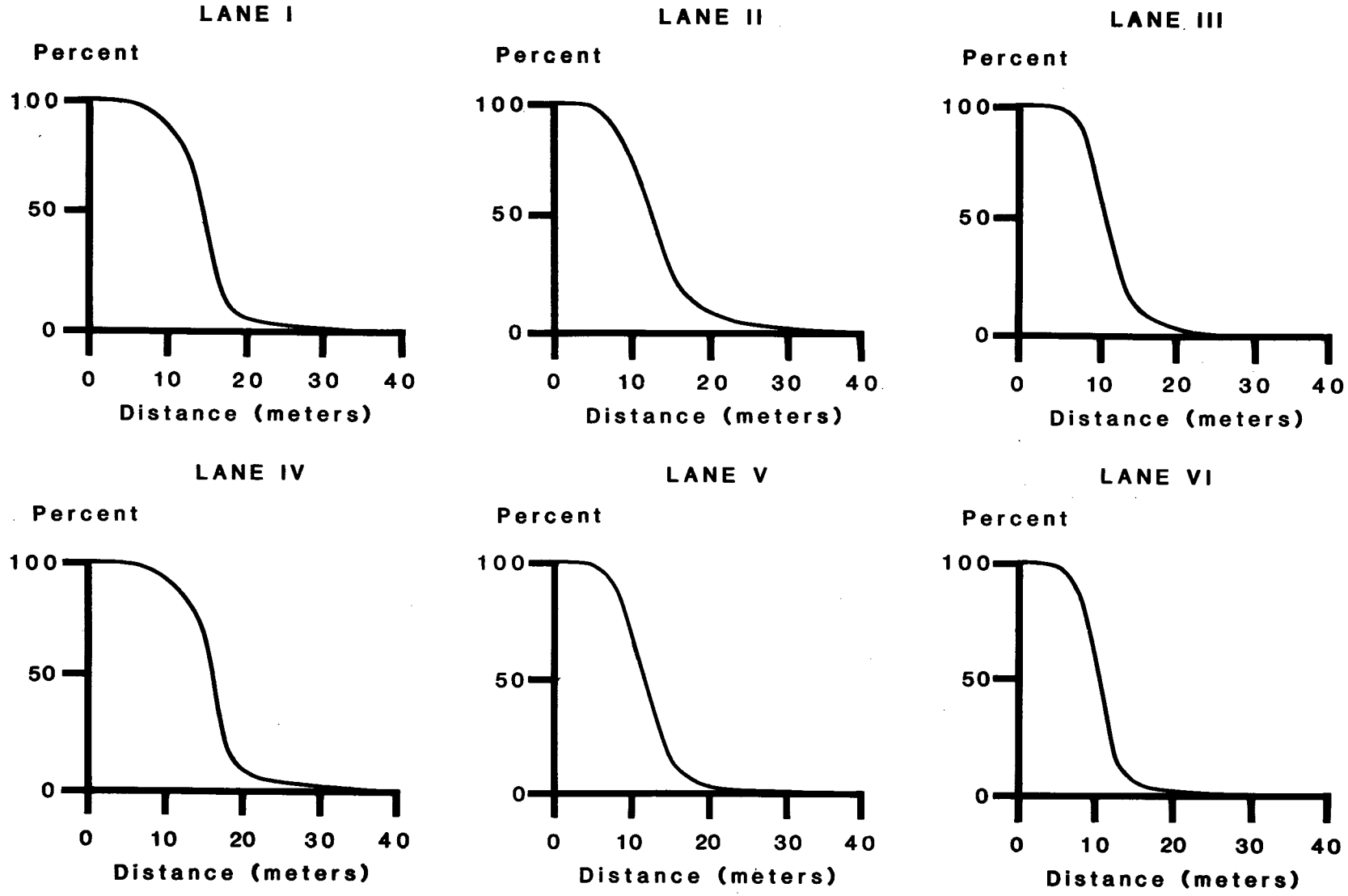

Figure 7. Detection Probability By Lane.

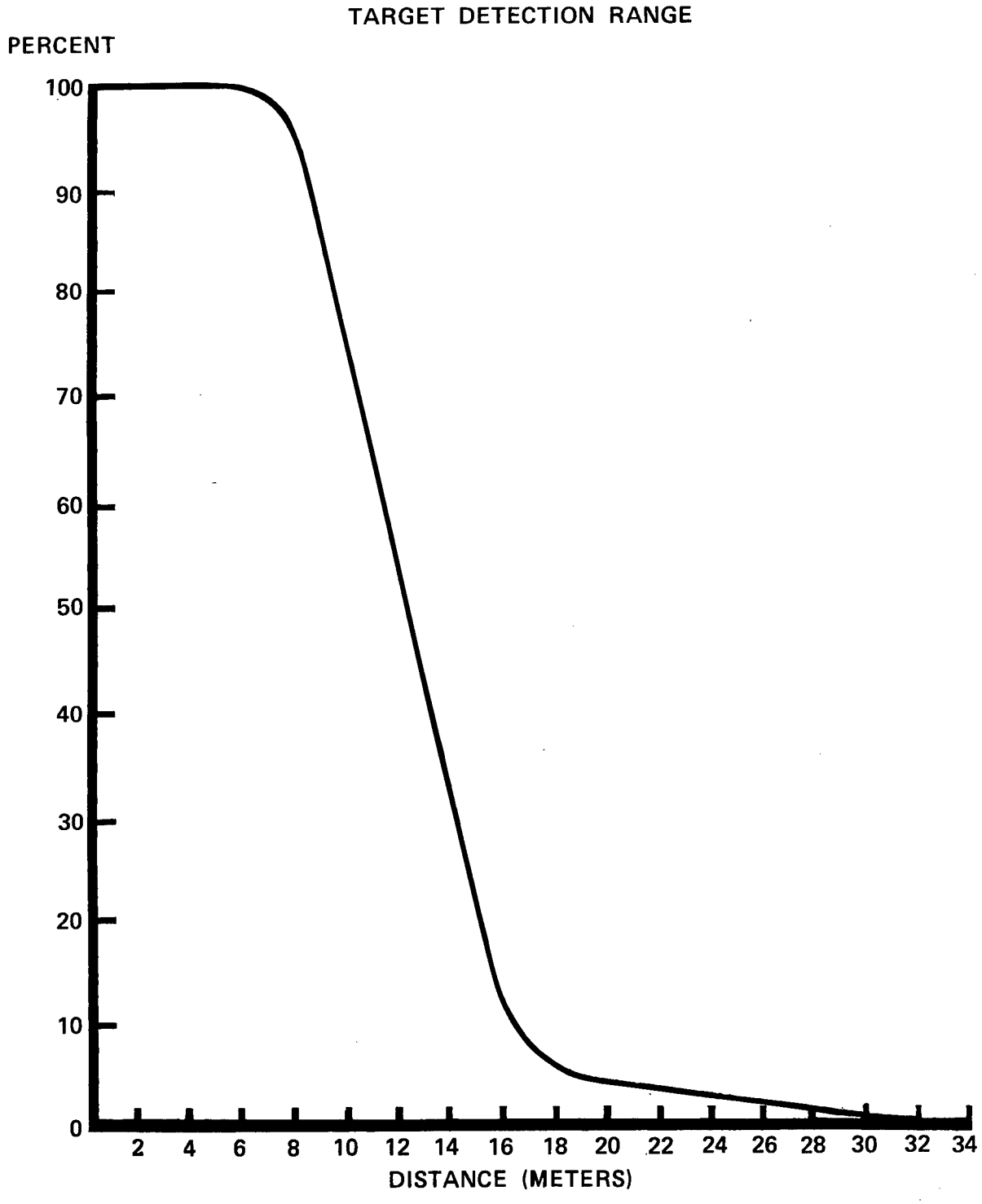

Figure 8. Detection Probability of All Lanes Combined.

TABLE 3. DETECTION DISTANCES PER LANE (N = 72)

Lane	Minimum (m)	Maximum (m)	Mean (m)	S.D.
I	7.12	31.28	14.26	3.11
II	7.28	29.50	14.00	5.25
III	7.12	23.71	12.95	2.76
IV	7.42	27.06	14.00	3.98
V	7.37	16.65	11.81	2.49
VI	7.11	22.02	10.81	2.89

S.D. = Standard Deviation

d. Analysis and Conclusion.

(1) The terrain is representative of lowland humid tropics and the site is relatively level. There are some locations where undesirable obstructions (large tree trunks and thick vegetation) occur. The maximum detection distance was 31.28 meters (on lane I), while the minimum detection distance was 7.11 meters (on lane VI).

(2) While some modifications are needed, the major relocation of the target detection site has proved successful. The target detection site has been validated conceptually.

e. Recommendations.

(1) Perform landscaping modifications to remove some of the obstructions and to fill some sparse spots to increase the variability of detections on some lanes.

(2) Evaluate methods of automatically transmitting data from the targets to the BOA to reduce data processing time and increase data accuracy.

2.5 SOUND LOCALIZATION SITE

a. Rationale. The sound localization site should afford a standardized, objective measure of aural directional detectability. The test site is required because some materiel items (e.g., helmet, ear protectors) may influence the ability of the soldier to determine the direction from which a sound is coming.

b. Description.

(1) The relocated site has the same characteristics as the old sound localization site. The new sound localization site is located in a reasonably level jungle area within the HFJTA. A four-lane test grid (figure 9) is used. The four radii of the grid intersect at 90-degree angles and are labeled north, south, east, or west. Speakers can be placed along each radius at one

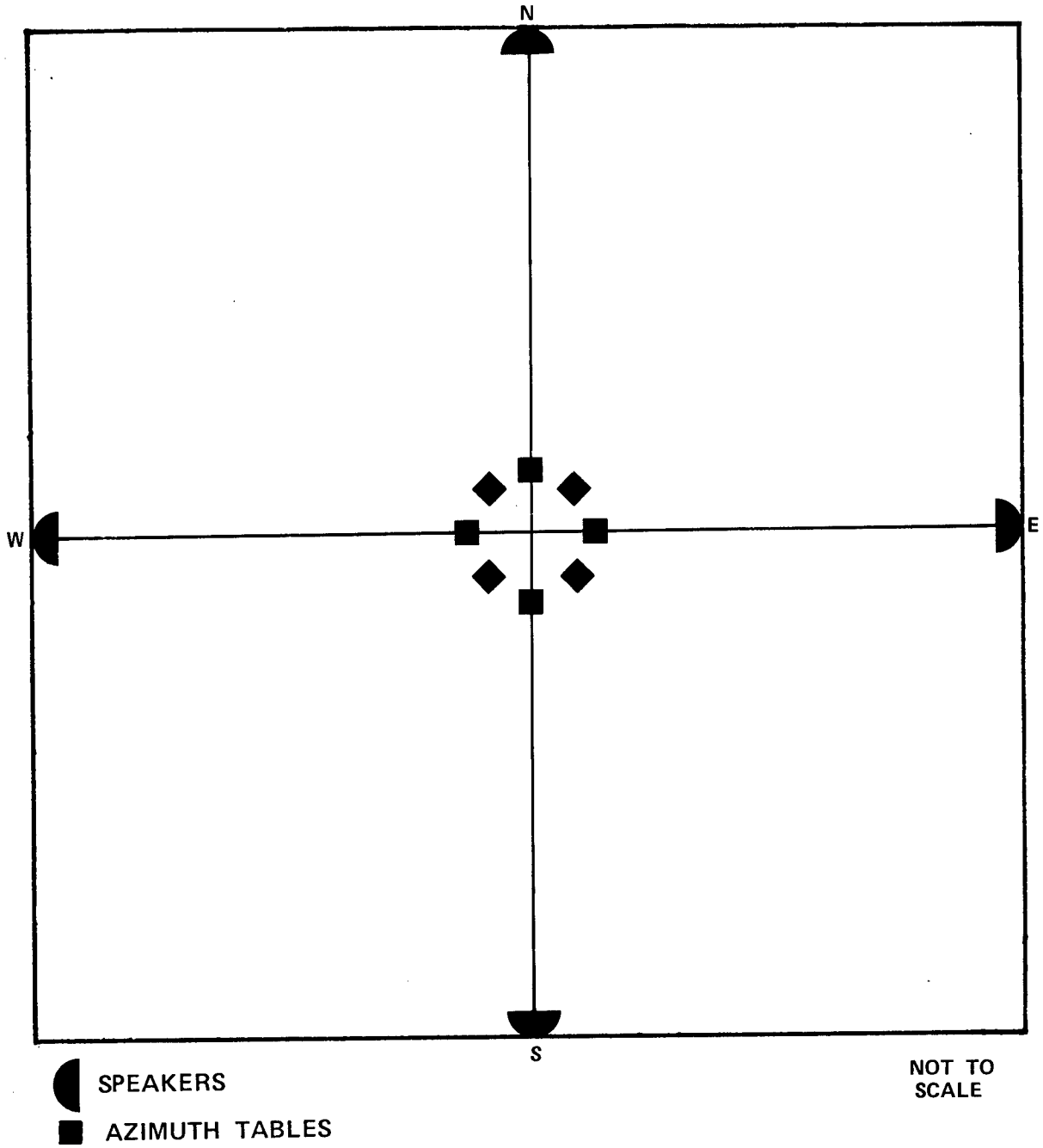

Figure 9. Diagram of Sound Localization Site.

of four distances: 30, 60, 90, or 120 meters. Sounds are generated from the ends of the four radii toward the intersection where listeners are positioned. At the intersection of the four radii, a 3-meter circular area has been cleared and eight azimuth tables (figure B-9) have been installed facing away from the center. All the tables are oriented so that the 0-degree mark points north and the 180-degree mark points south (figure B-9).

(2) Audio-generating equipment transmits sounds through high-quality, weather-proofed speakers from a remote location not visible to the listeners (figure B-10).

(3) Sound pressure level (SPL) readings are taken at the site to determine if the ambient noise is sufficiently below the SPLs generated during testing. Table 4 lists the ambient SPLs by octave band (N = 51).

TABLE 4. MEAN AMBIENT SPLs PER OCTAVE BAND

Sound Frequency (HZ 1/1 Octave)	SPL (dB) (20 μn/m²) Mean	Minimum	Maximum	S.D.
31.5	42.3	35	51	4.1
63	40.0	32	51	5.4
125	33.5	22	46	6.5
750	26.0	21	38	4.4
580	24.0	21	37	3.0
1000	25.0	22	33	2.5
2000	32.0	23	40	4.8
4000	53.0	23	65	10.0
8000	55.7	28	67	10.5
16000	38.2	15	53	9.9
All Pass	59.4	43	68	5.4

S.D. = Standard Deviation

c. Validation. Baseline data (mean and standard deviations for standard combat clothing) are broken out by reversal, nonreversal, and total error degrees in table 5. Reversals are those occasions where, because of the confused time differential of a sound reaching the two ears, a listener perceives the sound as coming from the opposite direction. These errors usually are considered as physiological and are not item related. Therefore, reversals are not considered in the overall analysis, but are analyzed separately for relevance to the specific item being tested.

d. Analysis and Conclusion.

(1) The sound localization site has been relocated. The terrain is relatively flat, and the vegetation prohibits visual detection of the

speakers. Speakers can be placed outward along each radius in 30-meter intervals up to 120 meters.

(2) The sound localization site has been validated conceptually.

TABLE 5. MEAN LOCALIZATION ERRORS (DEGREE)

Sound Type	Reversal			Nonreversal			Total	
	N	Mean	S.D.	N	Mean	S.D.	Mean	S.D.
Impact Sound (Machette)	17	150.294	29.725	239	14.573	18.677	23.586	39.038
Continuous Sound (Voices)	14	146.286	28.399	242	15.029	18.083	23.207	35.274
Lo Tone (125-Hz Pure Tone)	24	146.333	29.948	232	22.453	24.064	34.066	43.694
Hi Tone (2000-Hz Pure Tone)	54	132.185	28.896	202	27.416	25.107	49.516	50.046

S.D. = Standard Deviation

e. Recommendations.

(1) Explore a method to transmit the test participants' responses (azimuth indications) automatically from the test site to the base site for microprocessor reduction to reduce on-site personnel requirements, subsequent man-hour requirements, turnaround time, and errors.

(2) Develop a TOP for the sound localization site.

2.6 RIFLE MARKSMANSHIP SITE

a. Rationale. The rifle marksmanship site should be a permanent test site designed to represent a highly realistic, yet tightly controlled, scenario in which valid and reliable data can be collected. The data should provide quality information concerning time-to-fire and hit probability. The rifle marksmanship site should provide standardized objective measures of rifle marksmanship in either a stand-alone configuration or as a before and after measure in conjunction with the MPPC in the same manner as the land navigation site (as described in paragraph 2.3a).

b. Description. The relocated rifle marksmanship site differs from the old rifle marksmanship site in that the test participants do not remain stationary on the relocated site, but traverse a short path throughout which they engage targets. On the old rifle marksmanship site, the test participants stood still and engaged a field of targets which popped up at various distances in a 180-degree field of search. The deviation in site layout was instituted to increase the operational realism, and consequently, the credibility to test participants. The relocated rifle marksmanship site

consists of five pop-up target mechanisms located 15 or 30 meters out from a 90-meter winding trail (figure 10). Each target contains a laser sensing diode. A laser beam transmitter is attached to a mock-up M16. When the beam hits the sensing diode, it activates electronic circuitry in the receiver and drops the target, recording a hit. An electric sequencer is used to time target presentations. The sequencer is initiated manually from a visual vantage point. If a target is not hit during the specified time, the sequencer automatically puts it down. Target elevation and distances are given in table 6, below.

TABLE 6. TARGET DISTANCE, AZIMUTH, AND ELEVATION

Target No.	Target Distance (m)	Azimuth (deg)	Elevation (deg)
T1	15	52	-3
T2	30	225	11
T3	15	250	12
T4	15	22	-2
T5	30	180	4

c. Validation. Baseline data were gathered on the rifle marksmanship site. Before the test participant started the test, a set of instructions was given and several practice shots were allowed with the target set up 20 meters away. The course was then started. When firepoint one was reached, target one (T1) popped up. The test participant was given 5 seconds to search, aim, and fire once. If the target was hit, it dropped and triggered a timer that indicated the time to hit. If the target was missed, the test participant continued down the trail to the next target and the sequencer reset and lowered the target. Rifle marksmanship site time data are presented in table 7. Hit probability and related data are presented in table 8. Representative photographs are included in figures B-11 and B-12.

TABLE 7. RIFLE MARKSMANSHIP SITE TIME DATA

	Minimum	Maximum	Mean	S.D.
Time to Fire (seconds)	1.90	4.90	3.93	0.80
Time Through Course (minutes)	1.00	4.00	2.36	0.67

S.D. = Standard Deviation

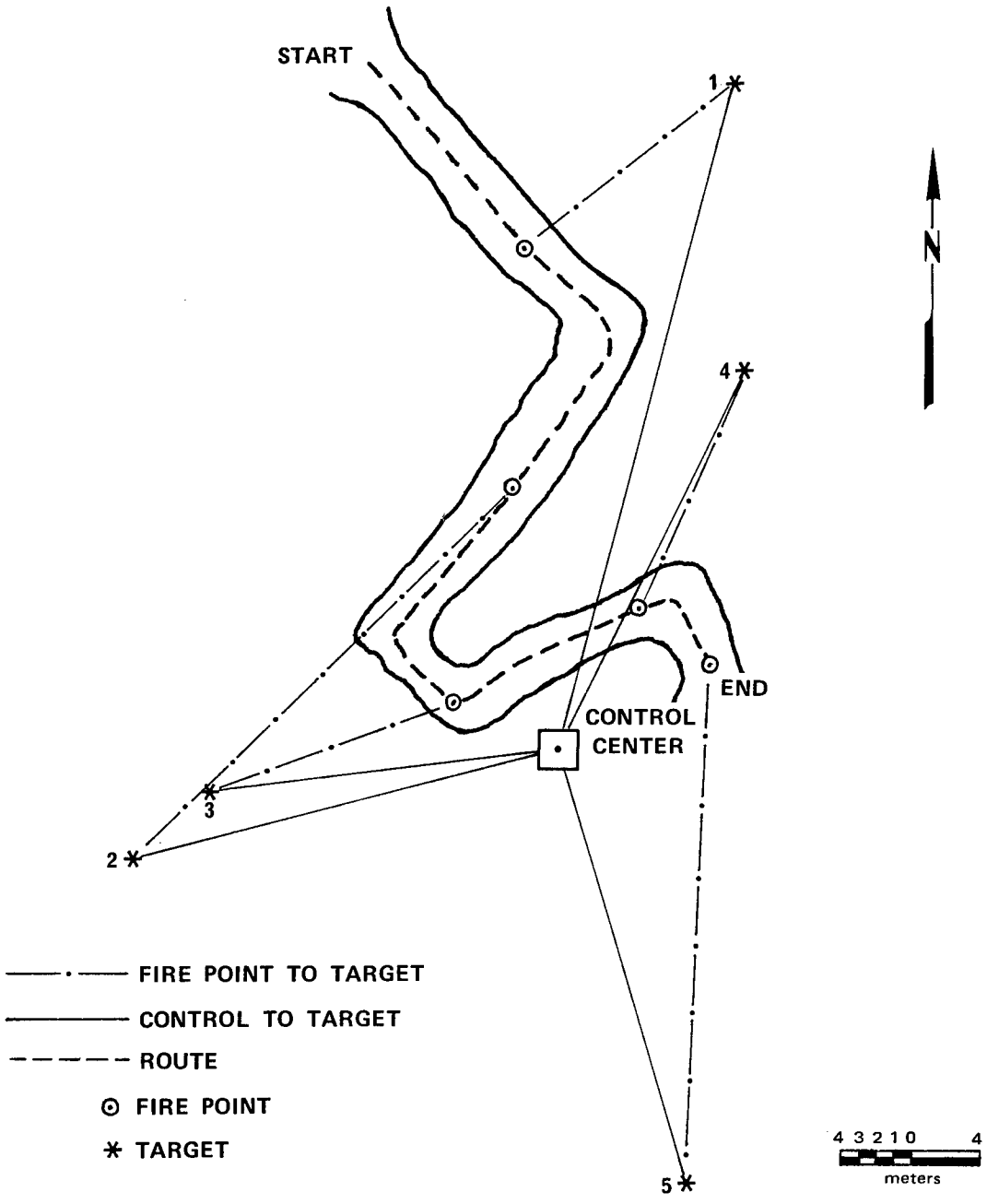

Figure 10. Diagram of Rifle Marksmanship Site.

TABLE 8. RIFLE MARKSMANSHIP DATA

Target Number	Not Detected	Detected	If Detected		Probability of Hit	If Hit Time to Hit	
			Hit	Miss		Mean (sec)	S.D. (sec)
1	1	65	7	59	.11	3.53	1.06
2	4	62	20	42	.32	4.54	0.59
3	5	61	17	44	.28	4.03	0.74
4	2	64	16	48	.25	3.59	0.86
5	12	54	10	44	.19	4.08	0.74
All Targets	24	306	70	237	.23	3.94	0.80

S.D. = Standard Deviation

c. Analysis and Conclusion.

(1) The rifle marksmanship site has been relocated and the changes have increased the operational realism and face validity of the task significantly. Consequently, soldier acceptance has increased.

(2) Comments from test participants indicate that operational realism and consequent soldier acceptance could be increased further by adding muzzle flash, report, and recoil. This could be accomplished by using blank-fire adaptors on M16s.

(3) In conducting the various analyses, the authors noted that the binomial hit/miss data base precluded using some of the more powerful statistical techniques that are applicable only with continuous-based, ratio-interval measures.

d. Recommendations.

(1) Consider firing blank ammunition to obtain a higher degree of realism in the rifle marksmanship site.

(2) Consider using other types of rifle-fire simulators, such as video instrumentation, to allow a more precise measure of rifle-fire accuracy.

SECTION 3. APPENDIXES

APPENDIX A. TEST DIRECTIVE AND METHODOLOGY INVESTIGATION PROPOSAL

(COPY)

DEPARTMENT OF THE ARMY
HEADQUARTERS, U.S. ARMY TEST AND EVALUATION COMMAND
ABERDEEN PROVING GROUND, MARYLAND 21005

DRSTE-AD-M 15 November 1979

SUBJECT: Directive, Human Factors Test Area Relocation, TRMS No. 7-CO-RDO-TT1-001

Commander
US Army Tropic Test Center
ATTN: STETC-TD-M
APO Miami 34004

1. Reference is made to TECOM Regulation 70-12, dated 1 June 1973.

2. This letter and attached STE Forms 1188 and 1189 (Incl 1) constitute a directive for the subject investigation under the TECOM Methodology Improvement Program 1T665702D625.

3. The MIP at Inclosure 2 and the attached guidance at Inclosure 3 are the bases for headquarters approval of the subject investigation.

4. Special Instructions:

a. All reporting will be in consonance with paragraph 9 of the reference. The final report, when applicable, will be submitted to this headquarters, ATTN: DRSTE-AD-M, in consonance with Test Event 52, STE Form 1189.

b. Recommendations of new TOPs or revisions to existing TOPs will be included as part of the recommendation section of the final report. Final decision on the scope of the TOP effort will be made by this headquarters as part of the report approval process.

c. The utilization of the funds provided to support the final investigation is governed by the rules of incremental funding.

d. The addressee will determine whether any classified information is involved and will assure that proper security measures are taken when appropriate.

DRSTE-CT-T 23 April 1981
SUBJECT: Directive, Human Factors Test Area Relocation, TRMS No. 7-CO-RDO-TT1-001

e. Upon receipt of this directive, test milestone schedules will be immediately reviewed in light of known other workload and projected available resources, in accordance with provisions of paragraph 2-4 to TECOM Regulation 70-8. If rescheduling is necessary, this headquarters, ATTN: DRSTE-TO-O, will be notified by 1st Indorsement not later than 15 November 1979. If schedules can be met, a P8 entry will be made directly into TRMS master file by that date.

f. The Methodology Improvement Division point-of-contact is Dr. Edgar M. Haverland, ATTN: DRSTE-AD-M, AUTOVON 283-2170/2375.

FOR THE COMMANDER:

/s/ Sidney Wise
/t/ SIDNEY WISE
Chief
Methodology Improvement Division
Analysis Directorate

3 Incl
as

(END COPY)
(Only Incl 2 is attached)

March 1979

(COPY)

1. TITLE. Human Factors Jungle Test Area Relocation

2. CATEGORY. Human Factors

3. INSTALLATION. US Army Tropic Test Center
P. O. Drawer 942
APO Miami 34004

4. PRINCIPAL INVESTIGATOR. Edgar M. Haverland
Materiel Test Division
STETC-TD-AB
AUTOVON 313-285-5912

5. STATEMENT OF THE PROBLEM. It is necessary to relocate the Human Factors Jungle Test Area (HFJTA) due to provisions of the new Panama Canal Treaty. The current Man-Pack Portability Course (MPPC), which is part of the HFJTA, lacks the flexibility required to provide the maximum challenge necessary to determine the effect of a newly developed piece of equipment on personnel movement in tropic jungles.

6. BACKGROUND. When the Panama Canal Treaty goes into effect (now projected to be 1 October 1979), the Gamboa test area where the US Army Tropic Test Center (USATTC) HFJTA is located will be under the jurisdiction of the Republic of Panama. Plans are being made to relocate USATTC facilities to areas which will be available during the life of the treaty (until 31 December 1999). This proposal is part of these plans. Facilities developed in the present HFJTA over the last eight years include: two four-kilometer manpack portability courses (MPPC), a rifle marksmanship range, a land navigation course, a ground-to-ground target detection range and a sound localization range. These facilities have been used in testing a wide variety of Army materiel and equipment.

7. GOAL. This effort will provide relocated facilities for human factors testing in an area that will be available during the life of the Panama Canal Treaty. Facilities will be modified, based on available terrain and experience with the present facilities. Particularly, it is planned to reconfigure the MPPC making it more vigorous and more flexible to allow maximum challenge under a variety of environmental and load conditions. Baseline data will be gathered on each of the test facilities after they are constructed. Changes will be necessary in TOP 1-3-550 and in TOP 1-1-054.

8. DESCRIPTION.

a. Suitable sites for the various facilities in the HFJTA will be located and surveyed, and the various courses and ranges will be constructed.

Consideration will be given to whether additional measured performances should be incorporated into the MPPC, and to whether facilities for additional performance tests, beyond the rifle marksmanship range and the land navigation course might be associated with the MPPC.

b. Sites with suitable characteristics for the various courses and ranges will be sought as follows:

(1) Manpack Portability Course. An area will be sought which incorporates the variety of terrain features typically encountered in the humid tropics. The course will be arranged so that it will begin and end near the test support and performance test areas. The present HFJTA contains two very similar MPPC's, but only one course will be constructed in the new area. The terrain sought for the new course will include stream crossings, hills, and jungle vegetation. Four types of activities are included in the existing MPPC: short performances of approximately 20 seconds to 3 minutes duration, long performances of 20 minutes or more, performances requiring normal effort, and performances requiring maximum effort. In designing the new MPPC, consideration will be given to activities of all four types. Some specific activities included in the present MPPC have not proved sensitive to different amounts or kinds of equipment and will be replaced in the new course with a somewhat extended or more difficult activities. Also, the following kinds of activities, different from those in the present MPPC, may be included in the new MPPC: a crawl of 50 meters under a barbed wire entanglement, crossing a stream using a one-rope bridge, and a climb up a very steep slope using a rope strung from tree to tree. The new course will be modular in construction so that the several different parts of it may be used individually, or in combination, depending on what seems most suitable for testing the particular equipment or materiel under the prevailing seasonal conditions. The Physiological Telemetry System, now under development, will provide real time safety monitoring on the course.

(2) Laser Rifle Range. The site for the laser rifle range will be located near the test support area where the MPPC begins and ends, since the laser rifle range is used in close conjunction with the MPPC to measure performance decrement resulting from the exertion of traversing the MPPC. The site will be laid out very much as the present laser rifle range is.*

(3) Land Navigation Course. The land navigation course will be located near the test support area where the MPPC begins and ends, since it is also used in conjunction with the MPPC. The land navigation course will be contained within a circle 50 meters in diameter. A reasonably level area of moderately thick jungle large enough for such a circle will be required for the land navigation course.

*Williamson, R. L. et al, Instrumentation for Human Factors Measurement in the Tropics III: A Rifle-Fire Simulator Test in the Jungle, USATTC Report No. 7603001, TECOM Project No. 7 COIL6 TT1 001, March 1976.

(4) Ground-to-Ground Target Detection Range. The site needed for the ground-to-ground target detection range will be a reasonably level area large enough for a half-circle of 40 meters radius. It should have enough vegetation in the understory so that an observer cannot see a person walking at a distance of 35-40 meters.

(5) Sound Localization Range. The site needed for the sound localization range will be a reasonably level area large enough so that loud speakers can be placed at distances of 30 meters from a central listening location in each of the four cardinal directions: north, east, south and west. The area should have abundant vegetation so that the loud speakers cannot be seen by listeners in the central location, and generally be representative of undisturbed jungle areas.

(6) Consideration will be given to additional standardized performance tests involving military activities, which might be administered in conjunction with the MPPC to measure performance decrement resulting from MPPC traversal.

As each of the test facilities is completed, baseline data will be gathered, using troops from the 193d Infantry Brigade (Canal Zone).

c. Milestones.

	FY 80				FY 81			
	1	2	3	4	1	2	3	4
(1) Survey and construct man-pack portability course	X	X						
(2) Survey and construct laser rifle range			X					
(3) Survey and construct land navigation course			X					
(4) Survey and construct ground-to-ground target detection range				X				
(5) Survey and construct sound localization range				X				
(6) Gather baseline data on man-pack portability course				X				
(7) Gather baseline data on rifle marksmanship range and land navigation course				X				

	FY 80 1 2 3 4	FY 81 1 2 3 4
(8) Gather baseline data on ground-to-ground target detection range and sound localization range		X
(9) Prepare revised TOPs		X

d. This effort will result in improved facilities for measuring human performance in the jungle.

9. PROGRESS. New Investigation.

10. JUSTIFICATION.

a. If this effort is not carried out in FY 80-81, USATTC will probably not have the facilities for standardized human performance testing in the jungle after FY 79. Also, carrying out this effort will help USATTC to be better able to assist other TECOM environmental test agencies in developing analogous, standardized human performance testing facilities.

b. Standardized human performance testing makes possible more sensitive tests of the effects of equipment and materiel on soldiers performance of their military duties. Dollar savings are impossible to estimate, but use of these realistic, objective tests will result in more valid decisions regarding the development and acquisition of equipment and materiel.

c. Over the last eight years the Tropic Test Center has carried out eight tests of individual equipment and weapons in which the HFJTA facilities were used. Current and likely future tests which would use these facilities are shown in the following schedule.

	Fiscal Year 79	80	81	82
XM29 Protective Mask	DT-II			
XM29 Chemical Agent Detector Paper	DT-II			
Physiological Telemetry System	SS	SS		
XM19 Sampler, Automatic Biological Agent Alarm		DT-II		
Remotely Monitored Sensor System		DT-II		
Detector Kit, Water Chemical Agents			DT-II	
Portable Mine Neutralization System			DT-II	
Advanced Respiratory Protection				DT-I

d. Recommended TRMS Priority: 1

11. RESOURCES.

a. Financial.

(1) Funding Breakdown.

Dollars (Thousands)

	FY80		FY81	
	In-House	Out-of-House	In-House	Out-of-House
Personnel Compensation	N/A		N/A	
Travel	1.5			
Contractual Support		31		
Consultants & Other Services		1		
Materials & Supplies	3			
Equipment	11.5			
Subtotals	16.0	32		
FY Totals	48			

2. Explanation of Cost Categories.

(a) Personnel Compensation. N/A

(b) Travel. It is intended to take two trips to Headquarters, TECOM, to discuss plans and progress on the construction of the facilities.

(c) Contractual Support. USATTC contract personnel will do the surveying and construction of the facilities, under the monitorship of the Research Psychologist, and will aid in gathering baseline data.

(d) Consultants & Other Services. The person from HQ, TECOM; who designed, monitored construction of and made extensive use of the present facilities in 1972-76; will spend two weeks at USATTC consulting on the planning of the new facilities. The funds in this category are intended to cover travel and per diem expenses for this person.

(e) Materials and Supplies. Miscellaneous materials for constructing the facilities.

(f) Equipment. The following equipment will be used in constructing the laser rifle range:

4 laser rifles @ $2000 (not a production item, specially made)	$8,000
6 target raise & lower mechanisms @ $500	3,000
Cables, switches and other electrical and electronic components	500

b. Anticipated delays. No delays are expected unless some of the equipment for the laser rifle range, which must be specially fabricated, takes more than six months to obtain.

c. Obligation Plan.

	FY80			FY81	
FQ	2	3	4	1	2
Obligation Rate (thousands)	31.7	7.3	9		

d. In-House Personnel

(1)

FY80

	Number	Man Hours Required	Man Hours Available	Study Hours Required
Research Psychologist, GS-0180	1	350	350	1560

FY81

	Number	Man Hours Required	Man Hours Available	Study Hours Required
Research Psychologist, GS-0186	1	400	400	1040

(2) Resolution of non-available personnel - NA

12. INVESTIGATION SCHEDULE.

	FY80											FY81										
	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S
In-House				-	-	-	-	-			-	-	-	-						R				
Contract				A	-	-	-	-	-															

13. ASSOCIATION WITH TOP PROGRAM. TOP 1-3-550 and TOP 1-1-054 will be revised as a result of this investigation. It is expected that one or more new TOPs will be prepared.

14. AUTHENTICATION.

/s/ Wendell L. Prince
/t/ WENDELL L. PRINCE
Colonel, Armor
Commanding

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APPENDIX B. TEST DATA

Part 1. Tabulated Data

TABLE B-1. SURVEY DATA (SLOPE) USATTC MANPACK PORTABILITY COURSE GAMBOA, PANAMA

OBSERVATION	MARKER FROM	MARKER TO	AZIMUTH (RELATIVE TO NORTH) (degrees)	HORIZONTAL DISTANCE (m)	ELEVATION (m)	SLOPE DISTANCE (m)	SLOPE (%)
1	1	2	242.9	10.6	-1.5	10.7	-14.2
2	2	3	321.9	12.1	1.2	12.2	9.9
3	3	4	307.7	10.7	-0.1	10.8	-0.9
4	4	5	325.2	11.8	-0.2	11.8	-1.7
5	5	6	296.1	14.2	-1.2	14.2	-8.5
6	6	7	254.7	11.9	0.9	12.0	7.6
7	7	8	220.5	7.1	-0.9	7.2	-12.7
8	8	9	211.0	10.3	-1.0	10.4	-9.7
9	9	10	182.2	9.4	-0.7	9.4	-7.4
10	10	11	208.8	13.2	-0.0	13.2	-0.1
11	11	12	209.6	10.2	-0.9	10.2	-8.8
12	12	13	185.2	9.5	-0.1	9.5	-1.1
13	13	14	172.3	14.0	-1.0	14.0	-7.1
14	14	15	179.4	4.9	0.0	4.9	0.0
15	15	16	170.3	11.3	0.5	11.3	4.4
16	16	17	180.1	7.6	2.0	7.8	26.5
17	17	18	172.4	8.5	1.0	8.6	11.7
18	18	19	177.9	5.3	0.4	5.3	7.6
19	19	20	165.6	8.9	0.0	9.0	0.0
20	20	21	155.5	5.2	0.6	5.2	11.6
21	21	22	277.5	9.8	1.3	9.9	13.3
22	22	23	261.0	7.7	1.2	7.8	15.7
23	23	24	220.6	4.9	0.3	4.9	6.1
24	24	25	168.5	11.0	0.5	11.0	4.6
25	25	26	199.5	10.3	1.0	10.4	9.7
26	26	27	202.3	10.3	0.8	10.3	7.8

Table B-1 (cont)

OBSERVATION	MARKER FROM	MARKER TO	AZIMUTH (RELATIVE TO NORTH) (degrees)	HORIZONTAL DISTANCE (m)	ELEVATION (m)	SLOPE DISTANCE (m)	SLOPE (%)
27	27	28	186.2	8.4	-3.2	9.0	-38.3
28	28	29	135.5	8.6	-2.8	9.0	-32.6
29	29	30	110.9	9.0	-1.8	9.2	-20.1
30	30	31	136.2	7.9	3.2	8.6	40.3
31	31	32	180.2	9.9	2.1	10.1	21.3
32	32	33	192.6	6.6	1.0	6.6	15.3
33	33	34	145.4	7.5	4.0	8.5	53.2
34	34	35	111.9	9.9	6.7	11.9	67.9
35	35	36	156.0	12.5	2.4	12.7	19.2
36	36	37	182.8	6.6	4.0	7.7	60.6
37	37	38	180.6	6.6	2.3	7.0	34.8
38	38	39	166.6	7.9	3.0	8.4	38.2
39	39	40	170.8	10.6	3.5	11.2	32.9
40	40	41	173.8	12.3	5.7	13.5	45.7
41	41	42	173.6	6.2	0.2	6.2	3.2
42	42	43	210.7	9.2	0.0	9.2	0.0
43	43	44	167.0	11.0	0.1	11.0	0.9
44	44	45	197.3	12.3	3.5	12.8	28.4
45	45	46	189.8	13.1	7.0	14.9	53.3
46	46	47	191.8	10.8	2.0	11.0	18.5
47	47	48	177.8	13.9	5.0	14.8	35.9
48	48	49	193.2	10.3	2.0	10.5	19.5
49	49	50	165.7	10.1	2.3	10.3	22.9
50	40	51	159.7	9.6	2.6	9.9	27.2
51	51	52	168.0	10.2	0.5	10.2	4.9
52	52	53	246.6	6.6	-3.5	7.5	-53.2
53	53	54	236.6	9.3	-3.0	9.8	-32.3
54	54	55	252.2	10.6	-3.8	11.3	-35.9
55	55	56	271.0	10.5	-4.5	11.5	-42.7
56	56	57	231.3	8.3	-6.0	10.3	-72.1
57	57	58	214.2	6.9	-4.0	8.0	-58.0
58	58	59	271.8	6.5	1.8	6.7	27.9
59	59	60	258.0	11.0	2.7	11.4	24.5

60	60	61	236.4	10.0	6.5	12.0	64.7
61	61	62	256.5	8.8	2.7	9.2	30.6
62	62	63	267.2	11.5	2.8	11.9	24.3
63	63	64	244.8	9.6	3.0	10.1	31.2
64	64	65	256.7	8.0	3.0	8.6	37.3
65	65	66	238.4	11.4	4.0	12.1	35.2
66	66	67	237.2	16.8	4.0	17.3	23.8
67	67	68	260.7	17.6	3.0	17.9	17.0
68	68	69	271.3	9.8	5.2	11.1	53.3
69	69	70	283.6	19.5	1.8	19.6	9.2
70	70	71	272.0	9.2	4.0	10.1	43.4
71	71	72	287.1	10.5	4.0	11.3	38.0
72	72	73	233.6	10.8	3.0	11.2	27.7
73	73	74	249.9	10.6	3.1	11.0	29.4
74	74	75	238.7	18.7	3.4	19.1	18.1
75	75	76	213.6	5.0	5.5	7.4	109.8
76	76	77	196.2	8.7	2.0	8.9	23.1
77	77	78	201.8	15.8	3.1	16.1	19.7
78	78	79	203.4	16.7	1.9	16.8	11.4
79	79	80	170.4	8.6	8.0	11.7	93.2
80	80	81	202.3	13.1	2.0	13.2	15.3
81	81	82	196.0	12.3	0.5	12.3	4.1
82	82	83	209.1	13.0	0.5	13.0	3.9
83	83	84	308.8	6.4	1.0	6.5	15.5
84	84	85	322.0	9.6	0.0	9.6	0.0
85	85	86	303.6	19.4	0.0	19.4	0.0
86	86	87	303.6	13.2	-3.0	13.5	-22.8
87	87	88	301.6	18.6	-1.5	18.7	-8.1
88	88	89	302.7	12.0	-3.0	12.4	-25.0
89	89	90	310.6	17.2	-1.5	17.3	-8.7
90	90	91	320.5	11.9	-2.5	12.2	-21.0
91	91	92	320.8	8.6	-1.5	8.8	-17.4
92	92	93	299.1	13.7	-3.0	14.1	-21.8
93	93	94	305.9	9.9	-2.5	10.3	-25.2
94	94	95	297.7	7.7	-1.0	7.7	-13.0
95	95	96	275.5	12.9	-2.3	13.1	-17.8
96	96	97	344.4	20.7	1.3	20.7	6.3
97	97	98	297.6	12.2	2.2	12.4	18.0
98	98	99	288.3	18.9	-0.1	18.9	-0.5

Table B-1 (cont)

OBSERVATION	MARKER FROM	MARKER TO	AZIMUTH (RELATIVE TO NORTH) (degrees)	HORIZONTAL DISTANCE (m)	ELEVATION (m)	SLOPE DISTANCE (m)	SLOPE (%)
99	99	100	283.6	18.8	-0.1	18.8	-0.5
100	100	101	294.4	13.2	0.5	13.2	3.8
101	101	102	309.2	10.2	-1.5	10.3	-14.8
102	102	103	310.9	16.7	-2.5	16.9	-15.0
103	103	104	312.2	12.5	-4.5	13.3	-36.0
104	104	105	323.0	12.1	-4.0	12.8	-33.0
105	105	106	336.8	9.4	-0.5	9.5	-5.3
106	106	107	14.8	8.9	0.5	9.0	5.6
107	107	108	2.8	9.2	0.5	9.2	5.4
108	108	109	355.2	13.6	0.5	133.6	3.8
109	109	110	346.2	7.9	-3.0	8.5	-38.3
110	110	111	307.9	18.5	-0.5	18.5	-2.7
111	111	112	2.1	9.4	-0.3	9.4	-3.2
112	112	113	26.2	10.6	-0.2	10.6	-1.9
113	113	114	34.1	6.1	-4.0	7.3	-65.6
114	114	115	29.3	7.8	-1.1	7.9	-14.0
115	115	116	26.6	8.0	2.1	8.3	26.3
116	116	117	333.2	6.9	-2.3	7.3	-33.3
117	117	118	5.6	7.5	2.0	7.7	26.8
118	118	119	7.4	8.1	0.2	8.1	2.5
119	119	120	25.8	6.7	1.3	6.8	19.5
120	120	121	353.5	4.0	-.0	4.0	-5.0
121	121	122	23.2	5.5	0.7	5.5	12.8
122	122	123	357.5	11.6	0.0	11.6	0.0
123	123	124	9.5	13.4	-1.0	13.4	-7.5
124	124	125	13.0	14.9	-3.5	15.3	-23.5
125	125	126	2.4	22.3	1.3	22.4	5.9
126	126	127	21.8	8.2	-2.8	8.6	-34.3
127	127	128	4.2	6.1	-2.0	6.4	-32.7
128	128	129	356.7	13.5	0.0	13.5	0.0
129	129	130	16.8	9.7	-0.7	9.7	-7.2
130	130	131	356.3	8.9	0.8	8.9	9.0

131	131	132	7.7	13.2	-1.0	13.2	-7.6
132	132	133	1.3	11.9	0.0	11.9	0.0
133	133	134	8.2	6.2	-1.0	6.3	-16.1
134	134	135	341.0	10.9	-4.5	11.8	-41.4
135	135	136	346.6	9.2	-1.5	9.3	-16.3
136	136	137	27.5	10.2	-3.0	10.6	-29.4
137	137	138	388.1	7.4	-2.0	7.7	-27.0
138	138	139	347.8	9.9	-4.5	10.8	-45.7
139	139	140	9.5	12.6	0.0	12.6	0.0
140	140	141	17.7	10.9	-1.5	11.0	-13.8
141	141	142	24.6	7.9	-0.1	7.9	-1.3
142	142	143	36.8	7.9	2.4	8.2	30.6
143	143	144	346.1	7.4	1.0	7.5	13.5
144	144	145	302.2	7.9	0.0	7.9	0.0
145	145	146	295.9	9.3	0.0	9.3	0.0
146	146	147	252.4	9.0	0.0	9.0	0.0
147	147	148	250.0	9.9	1.5	10.0	15.2
148	148	149	257.7	9.8	0.0	9.9	0.0
149	149	150	283.6	8.6	-0.5	8.7	-5.8
150	150	151	221.6	8.9	-3.5	9.5	-39.5
151	151	152	315.6	6.1	-5.0	7.9	-81.5
152	152	153	304.4	11.0	3.2	11.5	29.1
153	153	154	353.7	16.2	2.0	16.3	12.3
154	154	155	3.4	8.4	1.3	8.5	15.5
155	155	156	6.5	5.5	0.3	5.5	5.5
156	156	157	49.4	5.0	0.7	5.0	14.1
157	157	158	18.2	15.3	-0.4	15.3	-2.6
158	158	159	10.7	17.3	-2.0	17.4	-11.6
159	159	160	6.2	16.4	0.7	16.4	4.3
160	160	161	353.7	11.8	0.2	11.8	1.7
161	161	162	2.1	9.1	-1.0	9.1	-11.0
162	162	163	0.6	7.2	-2.0	7.5	-27.8
163	163	164	6.3	10.5	-2.3	10.8	-21.9
164	164	165	44.5	9.5	-1.5	9.7	-15.7
165	165	166	22.8	10.6	-2.5	10.9	-23.6
166	166	167	65.3	15.8	-4.2	16.3	-26.7
167	167	168	16.8	8.8	-3.5	9.5	-39.7
168	168	169	353.3	10.4	6.0	12.0	58.0
169	169	170	356.0	13.9	5.5	14.9	39.6

Table B-1 (cont)

OBSERVATION	MARKER FROM	MARKER TO	AZIMUTH (RELATIVE TO NORTH) (degrees)	HORIZONTAL DISTANCE (m)	ELEVATION (m)	SLOPE DISTANCE (m)	SLOPE (%)
170	170	171	2.6	8.9	4.0	9.7	45.1
171	171	172	16.0	13.7	1.0	13.7	7.3
172	172	173	4.8	11.6	2.0	11.8	17.2
173	173	174	13.4	7.8	1.0	7.8	12.9
174	174	175	350.7	7.3	2.0	7.6	27.3
175	175	176	17.0	13.7	-4.5	14.4	-33.0
176	176	177	359.3	12.3	-3.5	12.8	-28.5
177	177	178	15.3	11.0	-8.0	13.6	-72.6
178	178	179	340.7	14.3	-6.5	15.7	-45.5
179	179	180	16.3	9.0	4.6	10.1	51.1
180	180	181	32.8	9.1	3.5	9.8	38.4
181	181	182	11.9	14.5	1.5	14.5	10.4
182	182	183	10.6	10.2	1.0	10.3	9.8
183	183	184	355.9	15.1	2.2	15.3	14.6
184	184	185	31.1	7.3	0.5	7.3	6.8
185	185	186	335.1	7.3	1.0	7.3	13.8
186	187	187	6.4	7.0	1.8	7.2	25.8
187	187	188	35.5	8.7	1.0	8.8	11.5
188	188	189	340.3	8.8	0.8	8.8	9.2
189	189	190	3331.5	10.0	1.1	10.1	11.0
190	190	191	36.2	9.6	1.2	9.7	12.5
191	191	192	15.8	8.8	1.0	8.9	11.4
192	192	193	322.8	8.4	0.7	8.4	8.4
193	193	194	34.3	7.7	0.2	7.7	2.6
194	194	195	302.7	8.7	-0.5	8.7	-5.8
195	195	196	4.3	10.7	-4.0	11.4	-37.5
196	196	197	20.1	8.8	-1.0	8.8	-11.4
197	197	198	47.7	14.2	-4.0	14.7	-28.3
198	198	199	359.0	11.2	-3.0	11.6	-26.9
199	199	200	14.8	9.1	-5.0	10.4	-54.7
200	200	201	358.1	8.9	0.0	8.9	0.0

201	201	202	328.4	6.9	1.7	7.1	24.8
202	202	203	79.5	5.9	-4.5	7.4	-76.0
203	203	204	81.9	2.6	-3.0	4.0	116.0
204	204	205	4.9	6.9	0.0	6.9	0.0
205	205	206	338.8	9.8	0.5	9.9	5.1
206	206	207	26.5	4.8	5.0	7.0	103.7
207	207	208	48.4	9.6	4.5	10.6	47.1
208	208	209	24.3	8.4	3.5	9.1	41.5
209	209	210	12.4	7.3	2.0	7.6	27.4
210	210	211	81.5	10.3	0.4	10.3	3.9
211	211	212	70.6	8.6	2.0	8.8	23.2
212	212	213	55.7	6.3	0.4	6.3	6.4
213	213	214	24.0	9.0	1.2	9.1	13.3
214	214	215	44.2	8.8	2.3	9.1	26.2
215	215	216	26.8	9.1	1.0	9.1	11.0
216	216	217	20.9	7.2	2.4	7.6	33.3
217	217	218	26.3	8.6	0.5	8.6	5.8
218	218	219	25.4	7.1	0.0	7.1	0.0
219	219	220	30.7	9.0	0.0	9.0	0.0
220	220	221	30.0	8.5	0.4	8.5	4.7
221	221	222	44.7	8.5	-0.7	8.5	-8.3
222	222	223	38.7	9.2	-0.8	9.2	-8.7
223	223	224	48.2	9.5	-0.5	9.5	-5.3
224	224	225	36.8	7.8	-0.5	7.8	-6.4
225	225	226	116.3	8.5	-1.0	8.6	-11.8
226	226	227	63.2	6.2	-2.0	6.5	-32.3
227	227	228	53.5	7.3	-0.6	7.3	-8.2
228	228	229	68.1	8.2	-0.8	8.2	-9.8
229	229	230	48.8	6.4	-0.8	6.5	-12.4
230	230	231	55.2	7.0	-1.2	7.1	-17.1
231	231	232	97.4	7.5	-2.6	7.9	-34.7
232	232	233	120.8	8.8	-2.4	9.1	-27.5
233	233	234	120.6	8.8	-1.0	8.8	-11.4
234	234	235	154.4	6.5	-4.0	7.6	-62.0
235	235	236	140.1	6.6	-3.1	7.3	-47.3
236	236	237	141.2	8.4	-2.5	8.8	-29.6
237	237	238	156.9	7.6	-2.4	8.0	-31.5
238	238	239	122.0	7.0	-6.2	9.3	-89.0
239	293	240	128.3	9.2	-2.0	9.4	-21.8

Table B-1 (cont)

OBSERVATION	MARKER FROM	MARKER TO	AZIMUTH (RELATIVE TO NORTH) (degrees)	HORIZONTAL DISTANCE (m)	ELEVATION (m)	SLOPE DISTANCE (m)	SLOPE (%)
240	240	241	63.0	4.9	-3.0	5.7	-61.9
241	241	242	41.0	7.4	-2.0	7.7	-27.0
242	242	243	64.7	6.8	-3.6	7.7	-53.4
243	243	244	92.2	8.4	-1.4	8.5	-16.7
244	244	245	92.2	4.9	-2.5	5.5	-51.3
245	245	246	120.3	7.2	-1.5	7.3	-20.9
246	246	247	118.8	8.4	-1.0	8.4	-11.9
247	247	248	148.3	5.5	-3.8	6.7	-69.1
248	248	249	150.5	10.3	-0.9	10.3	08.8
249	249	250	142.5	4.7	-0.8	4.8	-17.0
250	250	251	80.1	6.9	-1.0	7.0	-14.4
251	251	252	116.9	9.0	-0.5	9.0	-5.5
252	252	253	131.3	10.4	-2.2	10.6	-21.1
253	253	254	123.3	8.2	-1.8	8.4	-21.8
254	254	255	121.8	7.6	-1.7	7.7	-22.5
255	255	256	110.0	6.9	-0.3	6.9	-4.3
256	256	257	127.8	10.0	-1.0	10.0	-10.0
257	257	258	127.5	7.5	-1.0	7.6	-13.3
258	258	259	110.8	6.3	0.0	6.3	0.0
259	259	260	118.8	7.7	-1.0	7.8	-13.0
260	260	261	105.4	12.2	-1.0	12.2	-8.2
261	261	262	193.0	9.4	1.0	9.5	10.6
262	262	263	191.1	8.2	-0.5	8.2	-6.1
263	263	264	181.6	7.8	-0.5	7.8	-6.4
264	264	265	212.7	7.0	0.0	7.0	0.0
265	265	266	185.2	11.4	-0.2	11.4	-1.8
266	266	267	199.7	7.5	-1.0	7.6	-13.3
267	267	268	189.9	7.3	-0.5	7.4	-6.8
268	268	269	155.7	8.9	-0.5	8.9	-5.6
269	269	270	168.7	8.9	0.0	8.9	0.0
270	270	271	137.3	9.9	-0.5	9.9	-5.1

271	271	272	115.8	11.3	0.5	11.4	4.4
272	272	273	138.8	9.9	0.0	9.9	0.0
273	273	274	143.7	8.3	0.0	8.3	0.0
274	274	275	176.6	8.2	1.0	8.2	12.2
275	275	276	145.0	4.7	-1.0	4.9	-21.1
276	276	277	144.9	6.9	0.3	6.9	4.3
277	277	278	145.0	9.6	0.2	9.6	2.1
278	278	279	130.8	9.6	-0.2	9.6	-2.1
279	279	280	143.2	9.0	0.5	9.0	5.6
280	280	281	170.3	6.4	-0.2	6.4	-3.1
281	281	282	184.1	7.1	-1.0	7.2	-14.0
282	282	283	153.5	14.9	-0.3	14.9	-2.0
283	283	284	200.6	23.2	-0.2	23.2	-0.9
284	284	285	154.2	11.7	0.1	11.7	1.1
285	285	286	229.4	12.0	0.3	12.0	-2.4
286	286	287	213.1	8.0	-0.8	8.0	-10.2
287	287	288	226.3	9.4	1.2	9.5	12.4
288	288	289	189.3	8.7	0.6	8.8	7.2
289	289	290	156.3	9.5	0.3	9.5	3.1
290	290	291	148.2	4.7	-0.5	4.7	-9.9
291	291	292	125.6	7.1	0.2	7.1	3.1
292	292	293	190.3	5.9	-1.2	6.0	-20.5
293	293	294	227.1	4.9	0.1	4.9	2.1
294	294	295	113.4	4.0	-0.2	4.0	-5.5
295	295	296	127.3	6.3	0.1	6.3	1.8
296	296	297	90.4	2.6	-0.2	2.6	-5.8
297	297	298	99.1	2.6	0.4	2.7	14.8
298	298	299	183.2	3.1	-0.1	3.1	-2.9
299	299	300	122.5	4.7	0.2	4.8	3.6
300	300	301	133.1	4.9	0.1	4.9	2.6
301	301	302	128.2	2.2	0.1	2.2	4.9
302	302	303	78.4	2.0	2.6	3.3	130.6
303	303	304	67.4	2.7	-0.1	2.7	-3.3
304	304	305	125.0	4.2	0.3	4.2	6.6
305	305	306	45.5	4.8	-0.1	4.8	-2.1
306	306	307	355.1	4.6	-1.6	4.9	-35.9
307	307	308	49.4	6.0	-0.5	6.1	-7.8
308	308	309	127.3	12.3	-0.4	12.3	-2.9
309	309	310	106.2	17.8	-0.0	17.8	-0.1

Table B-1 (cont)

OBSERVATION	MARKER FROM	MARKER TO	AZIMUTH (RELATIVE TO NORTH) (degrees)	HORIZONTAL DISTANCE (m)	ELEVATION (m)	SLOPE DISTANCE (m)	SLOPE (%)
310	310	311	69.5	19.7	-0.1	19.7	-0.6
311	311	312	186.1	7.7	1.0	7.7	13.2
312	312	313	204.4	6.3	0.6	6.3	8.7
313	313	314	130.4	9.9	1.2	10.0	11.6
314	314	315	173.5	5.7	1.6	5.9	28.2
315	315	316	137.3	5.8	-2.4	6.3	-41.9
316	316	317	143.0	10.3	4.9	11.4	47.9
317	317	318	155.3	7.6	0.7	7.7	8.9
318	318	319	127.0	4.2	0.1	4.2	2.1
319	319	320	166.1	17.7	-0.3	17.7	-1.7
320	320	321	166.2	8.7	-0.7	8.7	-7.9
321	321	322	163.1	7.5	-1.0	7.6	-13.9
322	322	323	163.0	6.5	-0.9	6.6	-13.0
323	323	324	195.6	8.2	-0.1	8.2	-1.2
324	324	325	123.2	3.5	-0.1	3.5	-2.9
325	325	326	89.2	7.8	-2.7	8.3	-34.6
326	326	327	80.4	5.5	-0.4	5.5	-6.9
327	327	328	185.0	14.2	0.5	14.2	3.3
328	328	329	158.5	12.3	-0.0	12.2	-0.3
329	329	330	166.4	5.0	-0.2	5.0	-3.4
330	330	331	325.2	8.2	-0.1	8.2	-1.5
331	331	332	180.1	7.1	2.4	7.5	33.7
332	332	333	250.3	3.9	-0.2	3.9	-4.4
333	333	334	229.1	5.5	-2.0	5.8	-37.1
334	334	335	191.0	9.6	1.8	9.8	19.1
335	335	336	96.2	8.8	1.1	9.0	12.0
336	336	337	131.3	5.9	1.9	6.2	31.6
337	337	338	212.1	8.4	1.8	8.6	21.0
338	338	339	236.5	3.1	-3.5	4.7	-115.6
339	339	340	237.2	4.2	4.0	5.8	95.4
340	340	341	188.3	5.9	0.6	5.9	9.4

341	341	342	197.2	4.4	0.4	4.4	8.4
342	342	343	241.2	4.9	1.1	5.1	22.3
343	343	344	285.2	5.7	1.5	5.9	26.4
344	344	345	304.5	2.9	0.4	3.0	13.3
345	345	346	324.3	5.9	-0.8	6.0	-13.5
346	346	347	324.2	4.3	-1.2	4.5	-26.8
347	347	348	22.5	4.8	1.7	5.1	34.7
348	348	349	237.5	8.7	2.6	9.1	29.9
349	349	350	264.1	7.7	2.2	8.0	28.9
350	350	351	204.3	3.2	1.2	3.5	38.4
351	351	352	213.0	5.7	1.5	5.9	26.3

TABLE B-2. SOIL ANALYSIS OF THE MANPACK PORTABILITY COURSE

Bulk samples of 2 to 3 kilograms were taken at each sample site for laboratory analysis and identified by soil type according to the Unified Soil Classification System. These samples also were used to determine the moisture content and density of the soil. Because these samples were taken during the rainy season (1 July to 15 September), they show the expected high moisture content. Samples should be taken at the same locations during the dry season to determine the change in moisture content.

Sample Number	Sample Represents Area from Marker No.	to Marker No.	Soil Classification USCS	Moisture Content Dry Weight (% dry weight)	Dry Density (lbs/ft^3)
1	1	8	CH	51.5	47.9
2	8	16	OH	91.4	36.6
3	16	30	CL	34.9	65.8
4	30	40	CL	37.6	62.3
5	40	51	CH	33.8	58.0
6	51	54	CL	32.8	71.4
7	54	58	CL	32.8	67.3
8	58	66	ML	50.4	51.3
9	66	72	MH	44.2	51.7
10	72	87	CL	91.1	31.6
11	87	102	OH	57.7	49.9
12	102	117	MH	52.4	55.8
13	117	132	MH	56.2	60.7
14	132	147	CH	73.8	50.1
15	147	162	OH	47.3	60.9
16	162	180	CH	67.1	48.8
17	180	200	CH	47.0	64.1
18	200	222	OH	54.3	61.3
19	222	237	OH	38.8	67.7
20	237	255	SM	28.9	81.7
21	255	270	CL	37.3	84.6
22	270	285	OH	95.5	49.5
23	285	300	CH	95.7	23.6
24	300	314	CH	88.6	44.9
25	314	327	CH	55.7	56.9
26	327	338	OH	61.2	51.2
27	338	352	CH	45.5	53.1

Legend:
MH = Inorganic silts, elastic silts.
ML = Inorganic silts.
CH = Inorganic clays of high plasticity, fat clays.
OH = Organic clays of high plasticity, organic silts.
CL = Inorganic clays of low to medium plasticity.
SM = Silty sands, sand-silt mixtures.

Part 2. Photographic Documentation

Figure B-1. Troop Traversing the MPPC.

Figure B-2. Troop Traversing the MPPC.

Figure B-3. Metal Stakes Outlining Land Navigation Site.

(1)

(2)

Figure B-4. Panoramic View from

(1)

Center of the Land Navigation Site.

(2)

Figure B-5. Test Participant Performing Task at Land Navigation Site.

Figure B-6. Observer Searching for Target at Target Detection Site.

Figure B-7. Observer Pointing at Target at Target Detection Site.

Figure B-8. Target Measuring Distance at Which He Was Detected at Target Detection Site.

Figure B-9. Tables at Sound Localization Site.

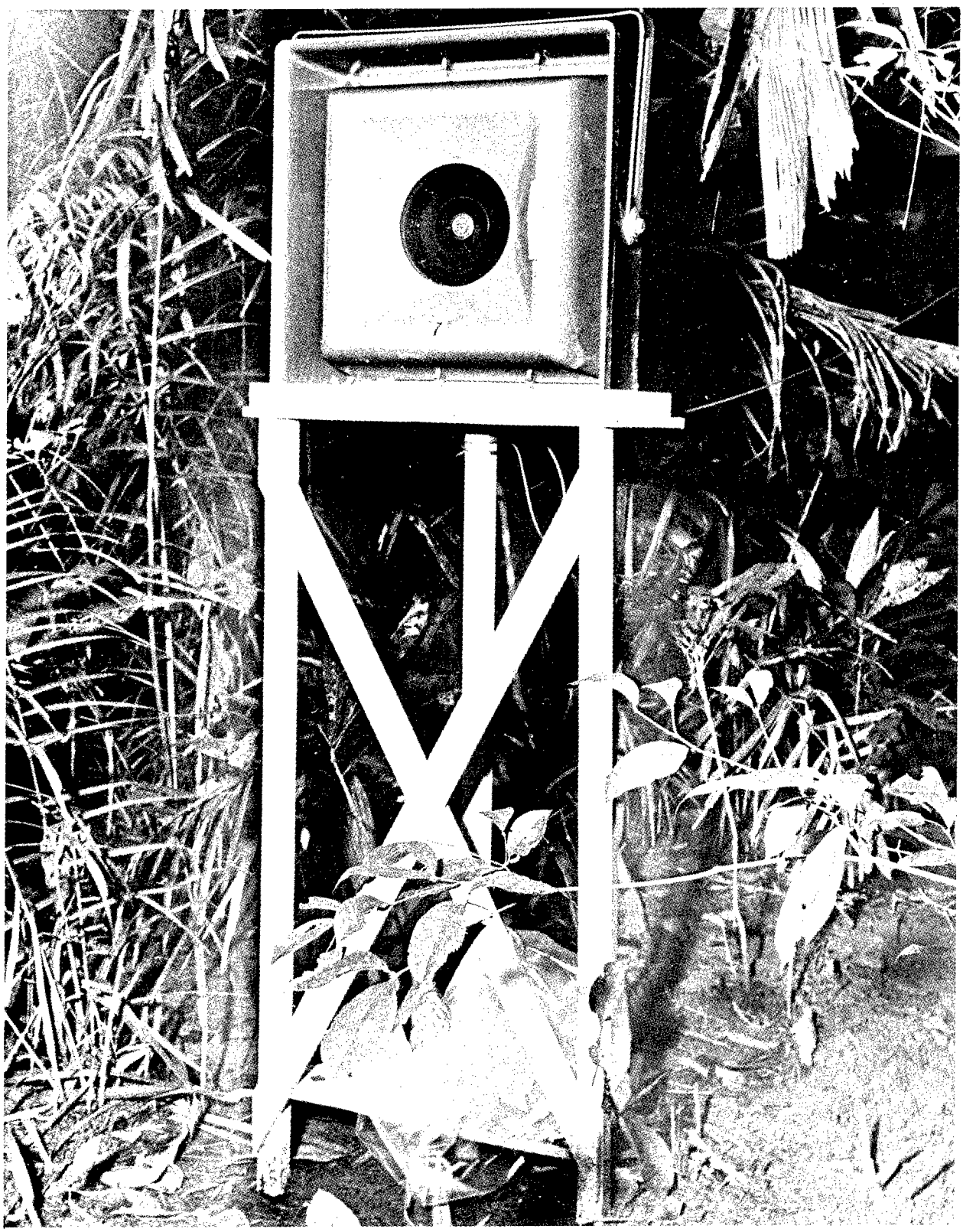

Figure B-10. Speaker at Sound Localization Site.

Figure B-11. Test Participant Engaging Target at Rifle Marksmanship Site.

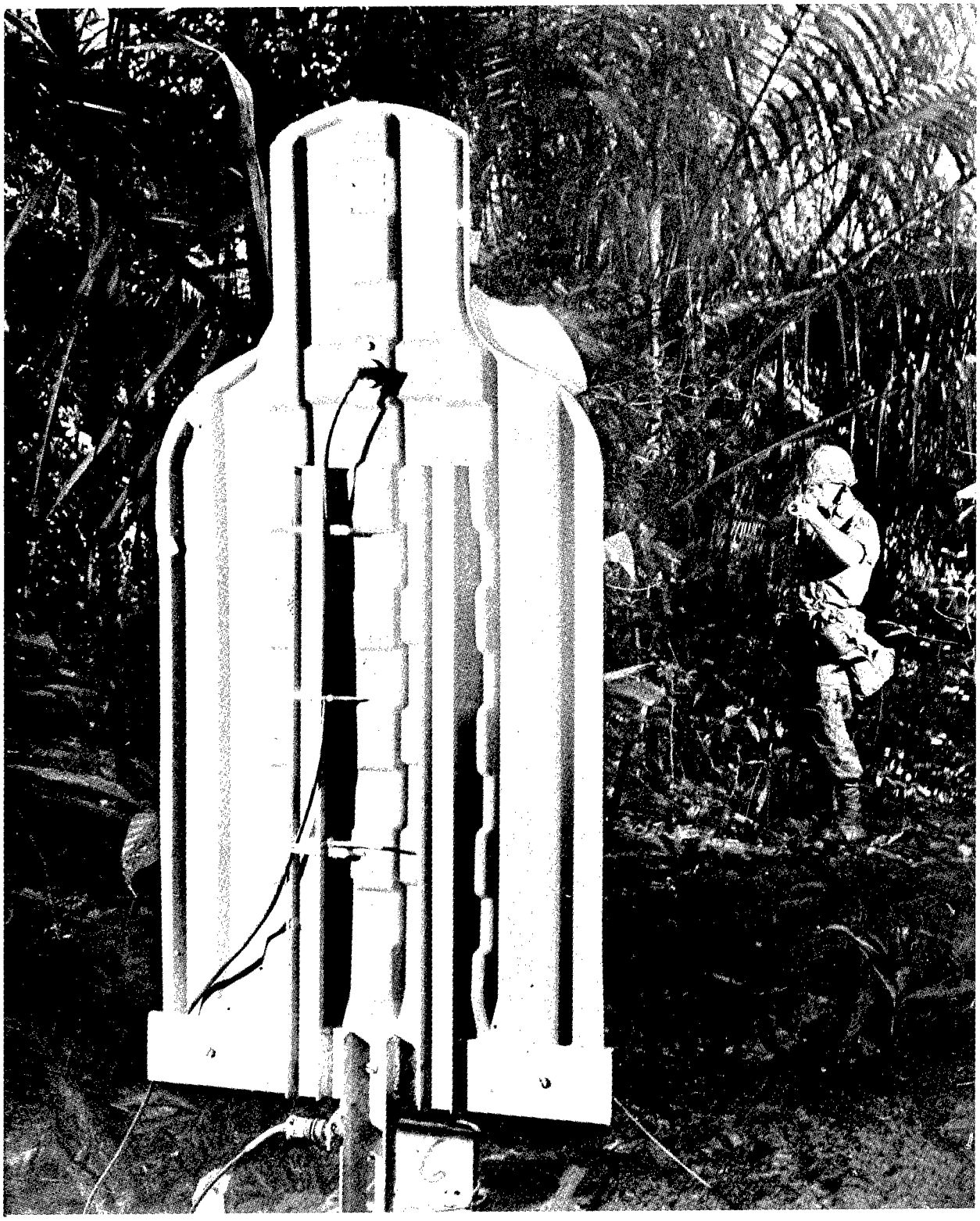

Figure B-12. Target Perspective at Rifle Marksmanship Site.

APPENDIX C. REFERENCES

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